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**THE EFFECT OF 'OPPORTUNITY-TO-LEARN' AND CLASSROOM
PEDAGOGY ON MATHEMATICS ACHIEVEMENT IN SCHOOLS
SERVING LOW SOCIO-ECONOMIC STATUS COMMUNITIES IN THE
CAPE PENINSULA**

**By
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**Thesis presented for the degree of
DOCTOR OF PHILOSOPHY**

**In the School of Education
Faculty of Humanities**

University of Cape Town

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FEBRUARY 2005

DECLARATION

I declare that *The effect of 'Opportunity-to-Learn' and classroom pedagogy on mathematics achievement in schools serving low socio-economic status communities in the Cape Peninsula* is my own work, except where indicated, and that it has not been submitted for any degree in any other university.

Signed:

Cheryl Ann Reeves

February 2005

ACKNOWLEDGEMENTS

I wish to acknowledge the following individuals and organizations:

Johan Muller, my supervisor, for his academic guidance, critical insights and incisive comments.

Greg Distiller of Statistical Consulting Services, Department of Statistical Sciences at the University of Cape Town for his invaluable assistance with statistical data analysis.

The schools, teachers and learners who so generously participated in the study and without whom this thesis would not have been possible.

The test administrators and others who assisted with data collection, in particular, Denric Blaauw, Lorraine Burgess, Donald Katz and Johnny Philander.

Dr Rudi Laugksch for his reading of the entire manuscript and his constructive comments. Mary Monteith for comments on earlier drafts.

Hilary Buchanan for her assistance with layout in the preparation of the dissertation, and Ingrid Thom, Chris Kleinsmith and Lance MacLeod for administrative and other assistance at the University of Cape Town.

Jhureen van Niekerk of the University of Cape Town's Information Communication Technology Services for her help with data capture.

The Western Cape Education Department for granting permission to conduct the research, in particular Peter Present and Ronald Cornelissen of the WCED for their time and assistance.

The South African and Industrial Leadership Initiative (SAILI) for its institutional support.

Jaamiah Galant for advice on her area of expertise.

Professor Tim Dunne for his suggestions and advice regarding statistical data analysis and Associate Professor Colin Tredoux and Heike Schmidt for their added input.

My Spencer PhD colleagues at University of Cape Town, in particular Heidi Bolton, Ursula Hoadley and Monica Mawoya for their companionship and collegiality.

Professor Martin Carnoy (Stanford University), Dr Luis Crouch, Professor James Ladwig (University of Newcastle), and Professor Tjeerd Plomp (University of Twente) for their comments at proposal stage.

The Spencer Foundation who supported me in my PhD research through a Spencer Fellowship grant for which I am extremely grateful.

Consortium Spencer Fellows for their ongoing comments on the study, and those academics who so generously gave of their time and expertise at the Consortium winter and summer schools.

Stanford University for inviting me to spend a month at the University whilst the work was in progress.

The Gatsby Charitable Foundation, the National Research Foundation and the University of Cape Town's University Research Committee for providing much needed funds to cover the cost of this fairly large scale research.

Finally, special appreciation goes to Keith Reeves, my family and close friends for keeping my spirits up and always giving me their support and encouragement.

Opinions and conclusions arrived at in the thesis are those of the author.

ABSTRACT

An assumption evident in South African education policy documents is that making available a learner-centred pedagogy is the most effective approach to improving educational quality in classrooms and achieving greater equality in achievement outcomes for socio-economically disadvantaged learners.

This thesis investigates whether the existing South African policy approach is supported through research, or whether, in accordance with the international evidence, 'Opportunity-to-Learn' (the curriculum content and skills actually made available to learners in classrooms) has a greater effect on achievement and is therefore a policy variable worth taking more seriously for narrowing the gap in achievement outcomes between South African learners of different socio-economic backgrounds.

The aim of the research is to establish whether 'Opportunity-to-Learn' or 'type of pedagogy' overall has more influence on mathematics achievement, or whether combinations of aspects of OTL and pedagogy have more influence. The work of Basil Bernstein provides the theoretical basis for discussing OTL and pedagogy within the same analytical framework so that the influences of each on achievement can be investigated and discussed using a common internal language of description.

The empirical work takes the form of a medium-scale study designed to compare the effect on achievement gains of naturally-occurring variations in the a) 'Opportunity-to-Learn' and b) 'type of pedagogy' made available to a representative sample of 1001 low socio-economic status grade 6 learners from four Cape Peninsula districts across one school year (2003). Main data sources are pre- and post-tests, classroom observations, learner work books and learner questionnaires. Statistical modeling is used to identify the relative effects of measures of 'Opportunity-to-Learn' and classroom pedagogy on the mathematics achievement gains of the sample to see which variables contribute the most to increases or decreases in achievement growth of low socio-economic status learners in a South African context.

Drawing on statistical evidence and a strong conceptual framework, evidence from the research does not confirm the principal assumption of the study but indicates that

combinations of aspects of OTL and pedagogy are associated with higher levels of gain. However, the pedagogical variables that are generally considered important and which are emphasised in South African curricular documents do not emerge as significant in the study. Furthermore, data exploration suggests that greater within and across grade content coverage (inter-grade pacing over a number of school years) may be associated with higher overall test scores rather than increases in gain across a single school year signalling that 'Opportunity-to-Learn' may 'work' more slowly over time. Indications are that across-grade effects of 'Opportunity-to-Learn' need to be considered in a research model which assesses cumulative effects of 'Opportunity-to-Learn' on achievement over a much longer period of time.

So I chose something mathematical, for this is universal, all can appreciate complexity, the
trance found in patterns of sounds.

From: The Piano Tuner by Daniel Mason, p.249

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LIST OF ABBREVIATIONS

BTES	Beginning Teacher Evaluation Study
C	Classification
C2005	Curriculum 2005
CORS	Center on the Organisation and Restructuring of Schools
CPI	Community and Parents Index
DET	Department of Education
EDMC	Education, Development and Management Centre
EMIS	Education Management Information System
F	Framing
FIMS	First International Mathematics Survey
FUM	Fully unconditional model
HLM	Hierarchical linear modeling
HoR	House of Representatives
HSRC	Human Science Research Council
ICC	Intraclass Correlation Coefficient
ID	Instructional discourse
IEA	International Association for the Evaluation of Educational Achievement
JET	Joint Education Trust
LA	Learning Area
LO	Learning Outcome
MC	Metropole Central
ME	Metropole East
MEC	Member of the Executive Council
MLA	Monitoring Learning Achievement
MLPPG	Mathematics Learning Programme Policy Guidelines
MN	Metropole North
MS	Metropole South
NDoE	National Department of Education
NGEO	Non-Governmental Educational Organisation
OBE	Outcomes-based-education

OTL	Opportunity-to-Learn
PCK	Pedagogic Content Knowledge
PEI	President's Education Initiative
QLP	Quality Learning Project
RD	Regulative discourse
RM	Regression modeling
RNCS	Revised National Curriculum Statements
SD	Standard Deviation
SEC	Survey of the Enacted Curriculum
SES	Socio-economic status
SIMS	Second International Maths Study
SRLS	School Reform Longitudinal Study
TCO	Test Curriculum Overlap
TIMSS	Third International Maths and Science Study
TIMSS-R	Third International Mathematics and Science Study-Repeat
USA	United States of America
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund – formerly the UN International Children's Emergency Fund
WCED	Western Cape Education Department

Chapter 1

INTRODUCTION TO THE STUDY

The aim of this study is to establish whether or not there is empirical support for the existing South African policy approach to improving academic outcomes in classrooms with learners from socio-economically disadvantaged backgrounds. This approach can be characterised as the promotion of a learner-centred pedagogy, which is explored more fully below.

The study arises out of concerns about the low academic performance of learners from socio-economically disadvantaged backgrounds in South Africa. In spite of well-intentioned efforts to improve schooling quality and close the race and class-related gap in achievement inherited from the previous apartheid system, high levels of under-performance and a strong relationship between poverty and low academic achievement are still starkly apparent in the results of internationally benchmarked comparative tests and learner testing conducted locally.

Achieving outcomes that ensure access to further educational opportunities and better-paying occupations for socio-economically disadvantaged learners poses an enormous challenge for the country as, unlike developed country contexts, it is the majority of learners rather than minorities who are disadvantaged.

1. RATIONALE FOR THE STUDY AND STATEMENT OF THE PROBLEM

1.1 Efforts to improve schooling quality in South Africa since 1994

So as to contextualize the study I broadly outline the main policy directions evident in efforts to improve schooling quality in the post-apartheid era.

Re-structuring, access and redress

Since 1994, when the new government came into power, much of South Africa's educational reform has been based on the political imperative for social equality and for redressing the educational inequalities of the apartheid past. For instance, the 'White Paper on Education and Training', published in Government Gazette No 16312 of 15 March 1995, stated that:

The state's resources must be deployed according to the principal of equity, so that they are used to provide essentially the same quality of learning opportunities. This is an inescapable duty upon government, in the light of this country's history and its legacy of inequality, and it is a constitutional requirement... (National Department of Education/NDoE, 1995: 21).

The South African government has been under severe pressure to address the legacy of apartheid by transforming a segregated and divided education system as quickly as possible and increasing black children's access to educational opportunities. Initially policy-makers focused on re-structuring the racially-based and financially unequal education system and re-organising the nineteen apartheid departments of education¹ into one national department and nine provincial sub-departments. Policy was mainly orientated around equalising formal access to schooling and inputs, in particular addressing the huge disparities in the distribution of resources inherited from the previous system through redistribution of funding to historically disadvantaged schools (Bot, 1999).

The policy focus was on increasing monetary allocations for previously disadvantaged schools; increasing spending so as to provide resources and amenities such as running water and electricity to schools²; upgrading teacher qualifications; and introducing national learner-teacher ratios through, for example, the National Norms and Standards for Funding Schools (National Department of Education/NDoE, 1998a), and Norms and Standards for Educators Acts (NDoE, 1998b). In other words, until more recently, the main means of promoting equality of educational opportunities in the South African schooling system has been by means of focusing on inputs rather than on outputs. Improvement in the learning outcomes of socio-economically disadvantaged learners was expected to follow naturally from the increases in inputs.

However, by the late 1990s, empirical evidence had begun to indicate that the 'vigorous redress measures' and 'increased flow of resources to the historically disadvantaged sectors' had 'had little if any effect on improving learning outcomes' (Taylor, 2001: 13). More specifically, pass rates at the end of grade 12 remained low and many learners disadvantaged

¹ Apartheid schooling was administered by separate departments for white, 'coloured' and Asian learners as well as for black learners living within 'white' South Africa and in each of the apartheid 'homelands'.

² Mechanisms such as the Register of School Needs have been used for this.

by apartheid were repeating grades or dropping out of school before they made it to grade 12 (Peacock, 1995; Schollar, 1999, Taylor & Vinjevold, 1999a, Seekings, 2001a). For example, data from the Education Management Information System (EMIS) indicated that in 1997 the average child spent 12,8 years in school, yet 'only one quarter to one third of any given age cohort get a standard 10 pass' (Seekings, 2001a: 9). According to the 'best estimates' it was taking 'some eighteen to twenty years to "produce" one Grade 12 enrollee, and some 36 years' to produce one grade 12 pass (Crouch & Mabogoane, 1997 in Seekings, 2001a: 9). What had become clear was that increasing expenditure and enhancing resources had not brought about the desired improvement in outcomes for disadvantaged learners.

Improving efficiency and effectiveness

Over time the policy focus shifted somewhat from earlier concerns with structural integration and more equal distribution of funding and resources, to include a concern with efficiency and effectiveness. 'Improving efficiency' is a key concept in economics and production function studies as it centres on the relationship between the cost of inputs, for example, the utilisation of resources such as 'time', relative to the outcomes produced. As Seekings (2001a: 74) points out the idea is that 'the fundamental objective of public investment in education is to produce higher levels of student achievement. The most important indicators of all are those that demonstrate how far students are achieving the desired performance goals.' In South Africa the focus has been on matriculation results at the end of grade 12.

Although school effectiveness research³ is a tradition of research that has been relatively weak in South Africa, a seminal study by Crouch & Mabogoane (1998) strongly indicated that it is 'poor school management' that is 'the largest single obstacle to overcoming the legacy of apartheid and providing equality of opportunity to all our citizens' (Taylor, 2001: 13). In 1997, these two researchers used the grade 12 results in two provinces in South Africa as a proxy for school effectiveness in a multi-factor regression analysis. They found that schools serving very poor communities tended to have grade 12 pass scores some 20% lower than schools in richer areas. Specifically, a school's being a former 'black' school, that is, former Department of Education and Training (DET), appeared to decrease grade 12 pass

³ School effectiveness research investigates the effectiveness of an educational system through external assessment of learner attainment in an attempt to identify sources of inefficiency and poor performance in schools and to establish indicators of how to improve learner achievement. The school effectiveness tradition of educational research is concerned with 'working aggregately across the system' (Muller & Roberts, 2000: 6) with its central question as to how different 'inputs' such as teachers and school resources affect learner achievement (Hanushek, 1995: 277).

rates by about 20-30%. After taking into account measures of poverty and resources, the researchers found that 20-30% of performance still remained unexplained. Their conclusion was that this unknown component could be accounted for by differences in 'managerial factors'⁴ (Crouch & Mabogoane, 1998). Indeed issues of poor management and leadership had similarly featured in a number of case studies, smaller-scale research projects and evaluations of interventions (see for example, Bateson, 1994; Schollar, 1995; Christie, 1998).

At the policy level, the state has tried to address the issue of inefficiency in management practices at schools and at Departmental district level through for example, Resolutions 7 and 8, passed in 1998 by the Education Labour Relations Council. These resolutions are orientated towards ensuring that schools and teachers are made accountable for more time being spent at school and in class (Fleisch, 1999). In 2001 the NDoE introduced Whole School Evaluation 'aimed at establishing the functionality of management practices in schools' (Taylor, 2001: 16). Also initiated by the National Department of Education in 2001 was a Systemic Evaluation System (NDoE, 2001 in Taylor *et al.*, 2003: 15) aimed at establishing systemic functionality through testing at the grade 3, 6 and 9 levels and signalling that matriculation results at the end of grade 12 were no longer seen as sufficient for monitoring the effectiveness of the whole schooling system. Evidence is that the management of schools is 'slowly improving' (Taylor *et al.*, 2003:13).

Improving accountability and outcomes

A further challenge that has faced South African policy makers is that the South African educational system, like education systems worldwide, has been subjected to the pressures of the global economic imperatives of international competitiveness. The system has come under increasing pressure to measure itself against global 'performance' standards (Muller & Roberts, 2000). Muller & Roberts (2000: 9) attribute this to the 'emergence of global score comparisons as a phenomenon linked to global economic competitiveness comparisons'. In particular, the Third International Maths and Science Study (TIMSS), sponsored by the International Association for the Evaluation of Educational Achievement (IEA), has placed

⁴ Although the length of the South African academic school year is comparable to that of other countries, researchers have reported that considerable time is lost to teaching in many schools (Taylor and Vinjevold, 1999a - see later in Chapter 2). School time is also lost to learning through high rates of learner absenteeism (Hoadley, 1999). For example, in the Western Cape, schools report 'spells of absence' on the part of learners whose parents form part of a migrant population that moves between the Eastern Cape and the Western Cape. Learners spend some time with one family member who lives in the Eastern Cape and some time with another who works in the Western Cape (Reeves, 2000). These learners either miss school or attend more than one school during the year.

comparative mathematics and science achievement in the spotlight through comparative measures of learner achievement in approximately 50 educational systems across five continents (Schmidt *et al.*, 1997 a & b).

Most technologically-based societies now recognize mathematics and science achievement as important for economic progress, and as Muller & Roberts (2000: 10) aver, 'poor results in studies such as TIMSS' are increasingly seen to signify 'poor global competitiveness in education and therefore economic performance'. They argue that 'the global market was clearly making itself felt here, and the effect was immediate; henceforth accountability would mean accountability to outcomes and quality.' Certainly, in the 1990s a worldwide concern with educational quality has meant that 'achievement outcomes are increasingly seen as the final measure of reform success and as publicly demonstrable accountable schooling practice' (Muller & Roberts, 2000: 2).⁵

In South Africa learners have performed poorly in internationally benchmarked comparative tests and in learner testing conducted locally. Results of testing repeatedly show that South African 'learner's scores are far below what is expected at all levels of the schooling system, both in relation to other countries (including other developing countries) and in relation to the expectations of the South African curriculum' (Taylor *et al.*, 2003: 41). For example, in 1995 South African learners tested in TIMSS 'came last' of the countries that participated in the TIMSS (Sunday Times, 17 July 2000; Howie & Hughes, 1998).⁶ In 1998, grade 8 learners who participated in TIMSS- R, a repeat of TIMSS, 'performed well below the levels of their counterparts' (Taylor *et al.*, 2003: 41). South Africa's learner performance was the worst of the 37 countries that participated (Seekings, 2001: 6). In 1999 the South African Monitoring Learning Achievement (MLA) Survey which formed part of the Joint International UNESCO/UNICEF monitoring learning-achievement project found grade 4 performance in

⁵ For example, in the USA, where results nationally in the TIMSS were found to be highly variable indicating 'pockets of excellence' (National Science Board, 1998: 1) but that, on average, not all learners had access to equal opportunities to learn more challenging mathematics and science content, the social justice call has increasingly been for greater equality in outcomes. The response has been a move towards a policy of school accountability that attempts to increase equity of opportunity to learn a common body of knowledge and skills and to reduce inequality in learning outcomes amongst the poor through the use of content standards and assessment measures to drive standardization of achievement (Elmore & Fuhrman, 1995). National Content Standards and Assessment Standards are being used as tools for raising performance expectations, measuring standardization of learner achievement and increasing equality in outcomes. According to Elmore & Fuhrman (1995: 6), in the United States 'equal access to essential services of compensatory efforts' are no longer seen as sufficient. 'With the development of state content and performance standards, policymakers in the USA have shifted the focus of their equity concern to outcomes' (*ibid*).

⁶ TIMSS testing in South Africa was limited to grades 7 and 8 and grade 12 (Seekings, 2001: 95).

literacy, numeracy and life skills tests 'poor' with the average score 'well below 50 percent' (Seekings, 2001a: 96). When the South African results are compared with eleven other African countries, learner achievement at the Grade 4 level 'appears to be far inferior to that in all these other African countries' (ibid: 8).

A number of local evaluations of school education programmes (for example, Schollar, 2001a; Kanjee *et al.* 2001) and research studies (see for example, Taylor & Vinjevoold, 1999) that involved learner testing have shown that, 'in relation to South African grade level benchmarks' many learners are performing 'below the expectations of the South African curriculum' (Taylor *et al.*, 2003: 43). Research evidence in the country has revealed high levels of under-preparedness, particularly amongst South African learners at schools in high poverty areas (Howie & Hughes, 1998; Joint Education Trust, 2000 & 2001; NDoE, 2002c; Cape Argus, 26 May 2004). Studies have shown that many Grade 6 learners in schools serving socio-economically disadvantaged communities 'are not able to perform mathematics and reading tasks expected at the Grade 3 level' (Joint Education Trust, 2001:3). In 2004 the Western Cape Education Minister (MEC) announced that results of systemic literacy and numeracy tests administered to grade 6 learners in the province in 2003⁷ showed a clear relationship between poverty and achievement – 'the poorer pupils, the more likely they were to lag' (Cape Argus, 26 May 2004).

Clearly the political and economic imperatives to provide effective schooling in South Africa that enhances achievement for all and improves the aggregate level of learning outcomes for the country are stronger than ever. Although there is increasing agreement internationally and locally of 'the centrality of achievement and importance of measuring outcomes' (Muller & Roberts, 2000: 25), the idea of becoming more globally competitive through an emphasis on academic performance has created some tensions for the social justice goal of redress and equity in South Africa (Christie, 1999). Of concern is that the needs of disadvantaged learners might be overlooked or neglected if the policy focus is mainly on outcomes as measured through learner performance on standardised tests.

Because the huge discrepancy in achievement outcomes linked to race and class is so glaringly evident (Taylor *et al.*, 2003), the use of measures that allow for comparative

⁷ Unlike other provinces in South Africa, the Western Cape Education Department's (WCED) systemic evaluation of grade 6 learners' mathematics performance commenced in 2003.

assessment of learner achievement across the education system is not just an accountability issue but also an important social justice goal. Achieving greater equality in those outcomes that ensure access to further learning opportunities and better-paying occupations for learners from disadvantaged backgrounds⁸ is thus both an economic goal and a social justice goal for the country.

Improving quality

Closing or at least substantially narrowing the significant race-and class-related gap in achievement outcomes⁹ will entail both improving accountability and efficiency across the system as well as educational quality in schools. If quality of opportunity issues are not addressed, the performance of disadvantaged learners in poor schools will not improve. Achieving greater equality in outcomes for South African learners will, of necessity, entail assisting schools across the system to 'deliver quality'. Therefore the next phase of school reform in South Africa is likely to focus on improving quality as indicated by achievement measures and on assisting schools across the system to 'deliver quality' (Fleisch, 2002). However, there is debate around how best to approach this.

Muller & Roberts (2000) explain that debates about how best to improve educational quality in the country and internationally are underpinned by the different assumptions underlying two main approaches to school reform. Those who see quality in terms of processes internal to individual schools such as the quality of organizational processes in schools and the quality of what happens in individual classrooms, want reform efforts based on an 'inside out' tradition where the focus is on 'whole school development' and the assumption is that it is 'inside' influences that impact on educational quality. Processes are seen as ends in themselves and impact on learning outcomes is seldom prioritised or assessed in models based on this tradition. At the policy level a difficulty with this approach is that improvement in one school or schools in a district does not necessarily improve the aggregate level of learner achievement for the entire country.

⁸ South Africa's score on the Gini index, which measures income inequality, 'is the second highest in the world after Swaziland' (Mail & Guardian, July 26 – August 1 2002: 4).

⁹ For example, Anderson *et al.* (2000 in Taylor, *et al.*, 2003) note that for 'younger cohorts (of the South African population) (my addition) nearly 90% of whites have completed grade 12 (matric) (my addition), compared with only 35% of Africans; similarly, pass rates in the matric exam are much lower for African students. In order to establish a measure for following children's progress through school, these authors calculate the number of grades completed per year of school attended for the different population groups. For Africans the value is around 0,80 grades per year for ages 10 to 16, while for whites the corresponding figure is around 0,94' (Taylor *et al.*, 2003 52-53).

In contrast, those who see educational quality as improving outcomes through accountability measures such as systemic assessment of learner performance in standardised tests and standardised 'inputs' such as standardised curricula, want reform efforts based on an 'outside in' tradition (Muller & Roberts, 2000: 6). Up until recently the characteristic response to either approach in South Africa has been zealous advocacy of one approach, and strong rejection of the other. The net result has been that, although the NDoE's Systemic Evaluation System was piloted in 2001 at Grade 3 level, the systemic assessment of learner achievement at the grade 3, 6 and 9 levels has not been fully implemented at the national level (Taylor *et al.*, 2003: 12).

What is increasingly evident is that successful educational reform needs to entail a 'systematically constructed combination of outside-in and inside-out approaches' (Taylor *et al.*, 2003: 5). Reform requires a 'combination of accountability and support measures' (*ibid*) through 'central policy mandates', such as 'system-wide standards', monitoring and systems of support that concentrates on assisting schools to achieve assessment standards (Fleisch, 2002: 95). Measures to improve outcomes such as an emphasis on efficiency (for example, through the introduction of measures to ensure that teachers and learners spend more time in schools and classrooms), effectiveness and accountability need to be accompanied by effective measures to improve the quality of teaching and learning in classrooms.

A further set of reform initiatives that have had an effect on the terrain of schooling quality since 1994 has been South Africa's curriculum policy.

1.1.1 The changing landscape of South Africa's curriculum policy and the prevailing pedagogical policy

The adoption of a new South African curriculum framework for grade 1-9 in 1997 formed part of the range of policy inputs developed to transform and restructure apartheid education (Christie, 1999: 281). Although the new curriculum, Curriculum 2005 (C2005), was essentially 'introduced to set aside the philosophical and pedagogical basis of apartheid-education once and for all', globalisation also played a role in the curriculum reform process (Chisholm *et al.*, 2000: 8). Policymakers looked to more developed Western countries such as Australia, New Zealand, Canada, the United States and Britain, where the emphasis in

education has generally been on 'individuality', 'creativity', 'flexibility' and 'freedom', to draw on conceptions of 'best practice' in education (Christie, 1999: 290).

The new South African curriculum is based on the concept of outcomes-based-education (OBE) and endeavors to promote non-racialism, non-sexism and democracy whilst creating active and critical citizens able to cope with the demands of the global workplace (Christie, 1999: 290). 1997 marked the adoption of a new curriculum framework that formed part of a range of policies developed to transform and restructure apartheid education in South Africa (ibid: 281). Where the 'apartheid' curriculum was based on traditional distinctions between subjects such as history and geography, C2005 integrates traditionally separate subjects into eight 'learning areas' – Human and Social Sciences; Numeracy and Mathematical Sciences; Natural and Physical Sciences; Economic and Management Sciences; Technology; Communication, Literacy and Languages; Culture, Arts and Artistic Crafts; and Life Orientation. Rather than outlining specific subject content and skills to be covered, the 1997 version of C2005 provides the outcomes to be evaluated or assessed for each learning area.

The previous apartheid curriculum took the form of prescriptive national syllabi for each subject that emphasized 'often ideologically distorted' academic subject content (Christie, 1999: 282) and disregarded the everyday realities of life in apartheid society. In contrast, the critical outcomes underpinning C2005, are 'open-ended' in that they emphasize 'higher order skills' such as critical thinking, the application of knowledge, problem-solving, and communication (Taylor, 1999a: 111 in Taylor & Vinjevold, 1999a).

C2005 integrates sixty six specific outcomes across the eight learning areas for the nine years of the three phases of General Education – Foundation Phase (grades 1-3), Intermediate Phase (grades 4-6) and Senior Phase (grades 7-9). The idea is that teachers choose the most appropriate content relevant to their particular learners' everyday lives for bringing about specific outcomes for each learning area (Fleisch: 2002: 9). For this the curriculum advocates strong integration between everyday and school knowledge and the use of five 'programme organizers', cross curricular themes derived from everyday life, for example, 'environment'. A premium is placed on integration of knowledge and 'transferability of knowledge to real life' (NDoE, 1997: 32). An assumption underpinning the new curriculum was that teachers had strong enough internalized conceptual schema to ensure that the

necessary specialized core knowledge and skills were made available to learners over their learning careers.

In 1998, when C2005 was in its second year of implementation, the NDoE through the President's Education Initiative (PEI) commissioned research to investigate the implementation of recent curriculum reform policies. The overall goal of the Project was to 'assist policy makers and practitioners to implement the good intentions of the new education system more effectively' (Joint Education Trust/JET, 2001: 1). In all, 35 individual small-scale studies were commissioned. The authors of the PEI's Report on all of the studies (Taylor & Vinjevoold, 1999a) concluded that curriculum efforts at integration between and across learning areas had resulted in a 'bewildering mix of concepts ... it seems most unlikely that learners will develop a systemic understanding of any of these ideas. In the hands of teachers whose own conceptual frames' of the subjects they teach 'are not strong, the results are likely to be disastrous where school knowledge is totally submerged in an unorganised confusion of contrived realism' (Taylor 1999a: 121 in Taylor & Vinjevoold, 1999a). The authors found C2005 to be 'highly prescriptive' in terms of pedagogy, and 'vague in the extreme in the area of content.' (ibid: 126).

At the heart of South Africa's new outcomes-based curriculum policy is an 'alternative' learner-centred approach to teaching. A learner-centred pedagogy is considered by many progressive members of the South African educational community to mark a shift from a more 'conventional' or 'traditional' teacher-centred pedagogy. Teacher-centred pedagogy is generally seen in terms of a 'transmission' or whole class teaching, authoritarian relations between teachers and learners, learner passivity, use of textbooks and drill and rote learning. This 'conservative' approach is associated with apartheid Christian National Education and its off-shoot, Fundamental Pedagogics, whilst a learner-centred 'progressive' approach is linked to the 'transformative' People's Education that emerged in the country in the 1980s. 'Progressive' pedagogy is seen to be 'based on an emancipatory vision in which learners take control of their own learning: they are active, creative and self-regulatory and reflective. Direct interventions by the teacher are seen as suspect and as interfering with the natural process. The role of the teacher is thus covert, i.e. he or she is seen as a guide and facilitator' (Taylor, 1999a: 108).

In South African curriculum documents, learner-centred pedagogy is described in terms of processes such as collaborative group work and independent hands-on activities linked to relevant everyday, real world problems. The content-based transmission model, on the other hand, is seen as treating learners as ‘empty vessels which have to be filled with knowledge’ (NDoE, 1997a: 30 in Kraak, 1999: 43). The idea is that, by ‘regarding learners as passive recipients or rote learners’, the model ‘deprives many learners of adequate opportunities to realise their full potential’ (NDoE, 1997a: 30 in Kraak, 1999: 43).

Table 1 taken from a C2005 document, reflects the way in which pedagogy has been conceptualised in South African curriculum documents and guidelines in terms of a dichotomous ‘from teacher-centred- to learner-centred’ model:

Table 1: The paradigmatic shift from transmission models of teaching and learning to outcomes-based education and training

	OLD TRANSMISSION MODEL OF LEARNING	NEW OUTCOMES-BASED MODEL OF LEARNING
THE LEARNER	Passive learners	Active learners
ASSESSMENT	Graded Exam-driven Exclusionary	Continuous Assessment; learners are assessed on an on-going basis
ROLE OF TEACHER	Teacher-centred, textbook bound	Learner-centred; teacher as facilitator; teacher constantly using group work and team work
CURRICULUM FRAMEWORK	Syllabus seen as rigid and non-negotiable Emphasis on what teacher hopes to achieve	Learning programmes seen as guides that allow teachers to be innovative and creative in designing programmes. Emphasis on outcomes- what the learner becomes and understands
TIME FRAMES AND LEARNER PACING	Content placed into rigid time frames	Flexible time frames allow learners to work at their own pace

Source: National Department of Education, 1997a: 6-7 in Kraak, 1999: 44)

Many curriculum planners, trainers and outside agents such as Non-Governmental Educational Organisations (NGEOs) similarly tend to portray ‘pedagogy’ in terms of this ‘either-or’ dichotomy actively favouring a ‘single pedagogy’ as the ideal teaching practice by encouraging teachers to promote learner participation through collaborative group work, co-operative problem-solving and hands-on activities in their lessons. The use of everyday knowledge or ‘real world’ contexts is endorsed as a pedagogical tool for inducting learners into formal school knowledge.

The authors of the President Education Initiative Report, however, portrayed this curriculum as driven by a strong pedagogical policy but weak conceptual coherence in terms of specialized school knowledge and skills and argued that this was likely to exacerbate rather than reduce existing inequalities in learning outcomes that ensure access to further educational opportunities for learners from disadvantaged backgrounds. The strong emphasis on relating scientific knowledge to everyday knowledge meant that the means of distinguishing scientific knowledge from everyday knowledge was not being made apparent to learners. Some PEI research studies had shown that 'in historically disadvantaged schools ... teaching through drill' had apparently been 'replaced by teaching about everyday life' which 'seldom translated into' specialized school knowledge (Fleisch, 2002: 118).

In 1999, in response to the findings of the PEI, a Review Committee was tasked by the Minister of Education with improving the quality of the curriculum and placing it on a more epistemologically sound footing. The Report of the Committee (Chisholm *et al.*, 2000) took issue with the weak 'lateral demarcation' (ibid: 41) between school and everyday knowledge and between different school subjects. A key recommendation of their Report was the decomposition of 'integrated' learning programmes into distinct subjects.

The Review Committee was further critical of the weak 'vertical demarcation' or under-specification of the curriculum in terms of conceptual coherence and 'sequence, pace and progression – what competences must be learnt' by grade level (Chisholm *et al.*, 2000: 40). They argued that the 'lack of a conceptual roadmap for proceeding' (Taylor *et al.*, 2003: 133) would principally disadvantage learners in schools where teachers' knowledge base was not strong. The Committee recommended stronger specification of the expected levels of competence for each grade level in the curriculum, especially for subjects with a strong vertical knowledge structure such as mathematics, natural sciences and languages. A further recommendation was greater alignment between the curriculum and assessment policy (Chisholm *et al.*, 2000).

Subsequent to the 2000 Review Report, C2005 has been re-defined through Revised National Curriculum Statements (RNCS) specific to each learning area (NDeO, 2002b). In the numeracy and mathematics Learning Area (NDeO, 2002a), the development of subject knowledge has been foregrounded and the statements now express the skills, concepts and

content learners are expected to have at each grade level.¹⁰ It seems likely that in future there will be greater accountability to the national assessment standards via clear national testing benchmarks. The idea is that learners are to be assessed against the national curriculum standards that indicate whether they have attained a learning outcome at an appropriate level for each grade. The reviewed curriculum is based on an assessment framework where learners are to be assessed on what they understand and know, and on their performance in tasks using new knowledge, skills and conceptual understanding.

Although, in 2003 when data collection for this study took place, the RNCS were not yet being implemented at the grade 6 level, the reviewed statements, certainly in the numeracy and mathematics Learning Area, mark a shift towards a more structured knowledge-based curriculum that focuses on attaining core skills and knowledge competences. In principle though, the pedagogy advocated for the implementation of the 1997 Curriculum 2005 remains in place for the implementation of the RNCS. In fact indications are that these pedagogical forms are strong enough to be called the 'ruling ideology' for improving the quality of the South African education system at the classroom level.¹¹ The assumption is that making available a learner-centred pedagogy is the most effective approach to improving educational quality in classrooms and achieving greater equality in learning outcomes for socio-economically disadvantaged learners.

Discussion

The core belief embedded in the reform policies and efforts discussed above is that learning outcomes are best promoted by methods such as 'working in groups, discussion amongst learners, the use of practical materials, and working with examples drawn from the experience of the learners' (Taylor & Vinjevold, 1999a: 65). The idea is that equity and redress as well as global competitiveness will be promoted through the use of such

¹⁰ Cooper *et al.* (1997: 3) point out that mathematics 'like other school subjects', is 'not fixed and unchanging'. Nevertheless, although 'what counts as school mathematics' and 'the cognitive demands made on children' changes over time (ibid), a 'central core concerning number, space, measure, etc' 'stays the same' (ibid).

¹¹ For example, a document, *Revised National Curriculum Statements: Frequently Asked Questions* (Media in Education Trust & Eastern Cape Department of Education, 2003: 6) on the online South African National Education portal launched by the Education Minister in 2005, states that 'the emphasis on participatory learner-centred and activity-based education remains the same.' Another article on the same portal, 'Managing the Curriculum' taken from a manual in *Towards Effective School Management* states

As learners and educators spend most their time in classrooms, the arrangement must be conducive to teaching and learning. The atmosphere in an OBE classroom looks far more casual than the old-style classrooms with its desks in straight lines and rows. There is an emphasis on co-operative and group learning, so the arrangement of furniture and resources needs to be convenient for that way of working. This also allows the educator to move around the room more freely and to interact with individual learners and groups more easily.' (KwaZulu-Natal DEC, 2003: 64).

pedagogical practices and that the historical legacy of inequality and huge variation in achievement outcomes inherited from the previous apartheid system is best addressed through these teaching practices. As a result, attention in South Africa has focused not so much on enhancing opportunities to learn specialized curricular knowledge but on whether learners are exposed to particular teaching methods.

Research work and evidence from the majority of evaluations of educational interventions in South Africa shows that, overall, teachers have at least taken up the outward forms of 'progressive' methodologies (Schollar, 1999: 102). They have shown that teachers have 'enthusiastically taken up group work, or that they no longer gave memorisation tasks, etc.' (ibid). Yet, in spite of this and other school reform efforts in the country, the South African education system does not appear to be improving in terms of academic outcomes.

A plausible explanation is that learner-centred approaches are not being properly implemented. Indeed Boaler's (1997) work in England, provides insights into the very high demands that 'teaching approaches based upon student investigations, exploration and discussion' confer upon teachers (ibid: 18) if such approaches are in fact 'to distribute achievement more equitably' (ibid: 2). Such demands are likely to present a particular challenge in contexts where the conceptual frames of teachers are weak.

Not surprisingly, in South Africa there is evidence of poor forms of learner-centred practices. Taylor *et al.* (2003: 62) point to studies such as that of Brodie *et al.* (2002) that have shown how South African teachers' 'deploy the empty forms of learner-centred practices' in their attempts to "take up" the form and substance of learner-centred practices' (Taylor *et al.*, 2003: 62). An evaluation of a Curriculum 2005 Grade 7 pilot project (Vinjevold, 2000 in Reeves, 2001) found that teachers' use of learner-centred methods 'wasted time'. Delays were caused by the handing out of a range of learning materials. Indirect exploratory instruction resulted in learners being asked to discuss topics of which they had little or no knowledge. Reporting back on group efforts often resulted in extensive repetition of the same content.

Other research has shown how the learner-centred methodologies advocated in curriculum documents create particular difficulties in typical South African school contexts (Taylor & Vinjevold, 1999a). For example, group work is particularly problematic in classes that have

large numbers of learners (Reeves, 1999). Some PEI studies found that teachers' efforts to involve learners in 'hands-on' activities and investigations tended to be undermined by learners' low levels of foundation knowledge in the learning areas or subjects (Taylor & Vinjevold, 1999a).

Whilst it is true that there is empirical evidence that implementation of the learner-centred methodologies advocated in curriculum documents has been constrained by conditions in classrooms and that implementation has often been inept, the high levels of under-performance of South African learners is too starkly apparent to attribute their poor performance merely to problems with implementation of learner-centred methods. In particular, the extremely poor performance amongst South African learners at schools in high poverty areas suggests that something more than this is happening in our classrooms. However, whilst qualitative and quantitative research on learner achievement conducted in developed countries make a very strong case for basing school reform on sound empirical evidence, in South Africa we have a poorly developed research tradition on classroom factors which impact on learner achievement.

1.2 A poor research base on classroom factors which impact on achievement

A recent review of factors which influence achievement in South Africa by Taylor *et al.* (2003) shows that much of the South African research lacks 'detail on specific factors' in the area of 'pedagogy which impact on learning' (ibid: 64-65). As Schollar (1999: 102) argues, although we have 'learned how to change teacher and pupil behaviour' in South Africa, we 'have learned remarkably little about how to consistently improve pupil achievement'.

In line with school effectiveness research internationally, a number of more recent studies in South Africa have shown that economic class, parental education and household wealth are all strong predictors of school success (Anderson *et al.*, 2001; Case & Deaton, 1999). School effectiveness research in developing country contexts shows that home background (social class, income, levels of mother's and father's education) has a big influence on learners' academic performance. The findings of the *Equality of opportunity* study conducted by the sociologist James Coleman and his team (Coleman *et al.*, 1966) in the USA showed that 'schools bring little to bear upon a child's achievement that is independent of his (sic) background and general social context' (ibid: 325). In 1967 the Plowden Report similarly showed that in Britain, family background and socio-economic status (SES) overshadow

school effects and are the main factors affecting achievement. Indeed home factors were strongly related to achievement in every country that participated in the IEA's TIMSS. Rowan (1999 cited in Porter & Smithson, 2001: 63) in a more recent large scale nationally representative study found that in the United States, 'prior achievement and SES accounted for as much as eighty percent of the variance in mean achievement among classrooms'.

Nevertheless, generally the standard of effectiveness research in developing countries such as South Africa is deemed weak. This is mainly because of 'highly variable' standards of data collection and analysis (Archer, 1995, 13), and because much of the analysis 'is not published in standard academic journals' and 'does not have that basic level of quality control (Hanushek, 1995: 280). Aggregated results on research in developing countries do, however, suggest that school and teacher factors make a larger positive difference 'in poor countries than they do in rich ones' (Kravis, Heston & Summers, 1982: 156, Heneveld & Craig, 1996 in Marshall & White, 2001: 3). It has been argued that, in contrast to industrialized countries, since schools and teachers in developing country settings provide most learners with the only exposure they have to the kinds of formal school knowledge assessed by standardised tests, schools and teachers must be 'at least partly responsible' for learner achievement in such tests' (Marshall & White, 2001: 3).

For example, Floden (2003: 255-256) argues that 'differences in family-based opportunities to learn' school-related knowledge 'may account for some of the well-documented associations between family background and achievement' so that what appears to researchers 'as an effect of schooling may sometimes come from out-of-school learning'. He also points out that children with illiterate parents are less likely to have pre-school and out-of-school opportunities to learn the crucial skills of reading and writing available to children of literate parents. Stevenson, Lee & Schweingruber (1999) take this argument further by elaborating on potential differences between out-of-school learning in developed and developing countries. These authors point out that:

In most industrialized countries the path to early literacy begins in the home and continues through formal instruction in school. There is an interdependence between the two sources, since formal instruction gains its full effectiveness on the foundation established and maintained by parents and family members. In many developing countries however, high rates of parental illiteracy make it impossible for parents to enter directly into the process of helping their children learn how to read. In these

societies, instruction in reading depends primarily on what the child encounters in school (ibid: 251).

The argument is that, in developing country contexts, good schooling can have a greater influence on academic outcomes than in industrialized country contexts. Certainly, in South Africa, evidence is that there are 'very poor schools' that 'perform above expectations with respect to matriculation pass rates' at the end of grade 12, 'when compared with schools in the same socio-economic bracket' (Taylor *et al.*, 2003: 64).¹² Thus, whilst a child's family background influences pre-school and away-from school opportunities to learn school-orientated knowledge and has a powerful effect on learner achievement, there is also evidence that good schooling *can* make a difference in terms of achievement. The question therefore becomes a) what part of the teaching and learning process has the main effect on achievement and b) which part/s is/are most amenable to policy intervention?

The purpose of this research is to try to identify those aspects of the teaching and learning process that have not so far been identified but that are susceptible to policy intervention aimed at improving the achievement of learners from socio-economically disadvantage backgrounds.

1.3 Two aspects of the teaching and learning process associated with achievement

Two main 'contenders' emerge as classroom factors for producing effects on outcomes. The contenders are 'Opportunity-to-Learn' (OTL) and 'type of pedagogy'. On the one hand, the progressive educational community in South Africa as well as progressive educators internationally favours a learner-centred pedagogy. On the other hand, one of the most consistent empirical findings in educational research internationally, most prominently in international comparative mathematics and science studies, is that 'Opportunity-to-Learn' is related to learner achievement, that is, the content and skills that are made available to them in the classroom (Shavelson *et al.*, 1989; Burstein, 1993; Schmidt, W. *et al.*, 2001).

¹² For example, Taylor *et al.* (2003: 64) cite work done by Van der Berg and Burger (2002) showing that 37 schools in the Western Cape with fees of less than R100 per year 'display the full range of variation' in grade 12 results.

1.3.1 'Opportunity-to-Learn' and achievement

In the early 1960s, the First International Mathematics Survey (FIMS) of the IEA identified OTL as the 'single-most powerful' source of achievement score variation (Husen, 1974 in Schmidt & McKnight, 1995: 344). A key finding of the Second International Maths Study (SIMS) was that, when 'cultural and instructional practices among the countries' were investigated to explain differences in performance, 'the only classroom or school variable to be significantly related to achievement growth was opportunity to learn measured as content coverage and content exposure' (Stevens, 1996: 1). 'Content coverage' refers to the topics and sub-topics actually taught and 'content exposure' refers to the amount of time spent on these contents.

Studies such as the FIMS, SIMS and TIMSS uniformly show that 'the degree of overlap' between the content of instruction and content tested (test-curriculum-overlap) is 'a consistent predictor of student achievement scores' (Rowan, 2002: 16). These results, combined with 'the results of more than 15 years of research' particularly in the USA that documented the empirical relationship between learner achievement and the content and the conceptual level at which the contents are taught, 'suggested that curriculum exposure could be an effective lever in efforts to improve student achievement and to distribute learning opportunities more equitably' (McDonnell, 1995: 308). The 'conceptual level' aspect of 'content coverage' is used to measure whether the cognitive demands of the work taught correspond to or are higher or lower than the expected levels.

Stevens (1996: 1) argues that, in contrast to much of the research in the United States prior to the 1990s that 'focused primarily on the relationship of race/ethnicity and poverty as the main contributors to students' academic achievement', early IEA studies of mathematics showed that OTL is significantly related to learners' academic achievement. This finding is significant both 'because race/ethnicity and poverty are not alterable variables' (ibid) and because it confirms the view that schooling can play a role in providing low SES or disadvantaged learners with the academic competencies they need for further learning.¹³

¹³ Hirsch (1999: 43) states that 'since some children are apter and harder-working than others, equality of educational opportunity does not mean that all students will make very high test scores'. Although, 'good schools' 'can never *entirely* (their italics) equalize educational opportunity' 'because the home is also a school, where students spend more time than in the official one. Other things being equal, students from good-home schools will always have an educational advantage over students from less-good-home-schools. Nonetheless, basic gaps in knowledge can be compensated for in the classroom, as the international data prove' (ibid 43-44).

OTL measured as 'content coverage' and 'content emphasis' is now widely recognised as 'a policy relevant curriculum variable' in a number of national education systems (Floden, 2003: 253). However, McDonnell (1995: 309) notes that since the mid 1980s, the construct has expanded as the 'large body of research on the determinants of student achievement' has suggested that OTL is defined not only by the curriculum content that learners are offered and the amount of contact time devoted to teaching the subject area. Two other dimensions prevalent in more recent OTL literature are 'curricular coherence' and 'curricular pacing', that is the organization and structure or sequencing and pacing of curriculum content.

'Curricular coherence' and 'curricular pacing' measure variations in the 'pacing' and 'sequencing' of the curricular content that is made available to learners. 'Curricular coherence' is the degree to which domain-specific or disciplinary content is systematically and sequentially presented to learners in terms of the conceptual coherence of its organization. 'Curricular pacing' measures the structuring and organization of curriculum across grades. The idea is that curricular pacing and coherence helps prevent a cumulative deficit in breadth and depth of subject knowledge (Smith *et al.*, 1998).

In 1988, the IEA report, *Science Achievement in Seventeen Countries*, 'evaluated national systems according to the equality of educational opportunity they provided children – a fairness rating for each system. This was a measure of the extent to which a nation educated children at all schools to an appropriate average level of achievement, regardless of location or social class. What was evident was that the systems that ranked high in fairness also ranked high in excellence; the best-performing systems were also the most equitable ones and used "core curricula"' (Hirsch, 1999: 41). Hirsch (*ibid*: 44) argues that 'it follows that a moderately high average achievement in all schools is a roughly accurate index to national educational fairness'.

For instance, among Finnish schools, 'only 2 percent of the schools showed below-standard average achievement; in Japan, it was 1 percent; in Korea, 5 percent; in Sweden, 1 percent; and in Hungary, 0 percent' (Hirsch, 1999: 44). Among 'the non-core countries, the percentage of schools below par were Australia, 8 percent; the Netherlands, 16 percent; England, 19 percent; and the United States, 30 percent' (*ibid*). The argument Hirsch (*ibid*: 42) makes is that 'success in achieving fairness is explained at least in part by the fact that national systems which have core curricula are able to provide a school-based education

which relies relatively less on the undependable home curriculum to supply the prior knowledge needed for learning in each grade’.

Whilst OTL has received attention in international comparative studies such as the TIMSS, ‘its use to date in developing countries has been limited. Few studies of academic achievement have incorporated explicit measures of OTL (the curriculum made available to learners), and most have relied on indirect ones such as total days worked in the school or teacher subject-matter knowledge’ (Marshall & White, 2001: 7). Since there have been no studies on OTL in SA, it is plausible that this factor is an influential if not decisive factor in learner achievement. This opens a path for fruitful exploration.

On the other hand, curriculum documents in South Africa as well as many members of the progressive community locally and much of the literature on pedagogy internationally promote a learner-centred pedagogy. In the following section, I discuss only that pedagogical literature that uses learner achievement as the criterion for success. Although there are other criteria for success or ‘making a difference’ besides achievement, I am most interested in identifying the pedagogical practices that are associated with this definition of success. For this reason I have deliberately limited the discussion to studies and reviews of studies that include the use of achievement measures as I am most interested in research that has the same criterion for success as OTL studies.

1.3.2 ‘Type of pedagogy’ and achievement

In developed Western countries, the debate regarding the effectiveness of learner-centred versus teacher-centred approaches reflected in South Africa’s curricular documents is not a recent one. The polarized ‘either teacher-centred or learner-centred’ model of pedagogy evident in South African curriculum documents is also evident in debates around pedagogy in developed country contexts. For example, in the 1970s, when proponents of ‘informal education’¹⁴ were promoting a ‘new’ learner-centred education in elementary schools as ‘an effective way to improve the acquisition of higher cognitive processes through an intensified focus on student reasoning and creativity’ (Chall, 2000: 41), Rosenshine & Berliner (1978: 14) reported the results from research conducted in the early 70s on ‘learner-centred’

¹⁴ ‘Informal’ education, like learner-centred education, proposed that ‘students be guided to follow their unique interests and to work at their own individual pace’ (Chall, 2000: 41).

pedagogical variables such as, learner 'choice of activity'; 'grouping students' and 'classroom interaction' and learner achievement.

Their review of studies on 'student choice of activity' (ibid: 9), showed that 'classrooms which are organised so that students have a great deal of choice about the activities they will pursue are usually ones with lower academic engaged time and lower achievement'. The article, *Academic Engaged Time* which cites studies such as Soar (1973) and Stallings & Kaskowitz (1974), states that 'the more successful teachers directed activities without giving their students choices, approached the subject matter in a direct, businesslike way' and 'occupied the center of attention' (Rosenshine & Berliner, 1978: 8).

Rosenshine & Berliner (1978: 8) concluded from their review of studies on 'grouping students for learning' that 'as many students do not engage in on-task behavior unless a teacher or another adult is monitoring their academic activities, the use of large-group settings allow for more adult supervision. Although many educators prefer that teachers work with one or two children at a time, the reality is that when teachers are working with only one or two children, they are unable to provide supervision for the remaining children, and, as a result, children have less academic engaged time' (ibid: 8-9).

The reviewers cite a study by Stallings & Kaskowitz (1974) which looked at classroom process variables related to reading and mathematics on first and third grade achievement gains. Findings showed that 'time spent on activities involving group time'... 'or child selection of seating or workgroups always yielded negative results' in reading and mathematics achievement (Rosenshine & Berliner, 1978: 7). A possible explanation posed by the researchers was that when a variety of activities are going on in the classroom, learners are not properly supervised by the teacher and learners 'find it difficult to stay on task for a productive period of time' (ibid).

Rosenshine & Berliner point out that the results reviewed 'do *not* mean that all attempts at informality were disastrous, but rather that extremes of student autonomy and self direction were usually associated with less task orientation and student engagement and, consequently, less student gain on all measures' (ibid: 9 – their italics). They conclude that 'the critical variable' for acquisition of school knowledge and learner achievement 'is content covered and academic engaged time' and that 'a teacher can use any blend' of teaching approaches

‘so long as sufficient academic engaged minutes are obtained’ (ibid: 14). The inference that can be drawn from conclusions such as their review of this literature is that, as far as learner achievement is concerned, pedagogical type does not matter as long as opportunity to learn domain specific knowledge and skills is high. Indeed a study in South Africa by Maja (1998) similarly argued that whether a teacher’s approach is teacher-centred or learner-centred ‘does not seem to relate in any way to performance’ (Taylor & Vinjevold, 1999b: 156).

Jeanne Chall (2000), in a more recent review of the evidence, argues that teacher-centred approaches are much more likely to improve academic achievement and provide low SES learners with opportunities for further learning, higher education and occupational success. In *The Academic Achievement Challenge: What really works in the classroom?*, Chall (2000) distinguishes between two sets of educational ‘practices and philosophies’ that ‘have emerged over the past century’ (ibid: 6) – the ‘traditional’ or ‘teacher-centred’ and the ‘new’, ‘progressive’, ‘student-centred’ education. She presents each pedagogical type as ideals ‘that do not necessarily exist in reality’ (ibid: 11) and reviews a ‘variety of evidence – historical accounts, descriptive and qualitative observations, reports of teachers and parents, as well as quantitative research’ in an effort to establish that ‘one approach is more effective than the other’ for academic achievement (ibid: 2). Her report examined ‘comparisons between school practices in America, and those in Europe and Asia, and looked for evidence of how much different backgrounds, abilities and grade placements of students appeared to matter’ (ibid: 12).

With regard to whether a teacher-centred or learner-centred emphasis is superior for student achievement, Chall (2000) found that only a few studies have actually ‘compared the achievement of students exposed to either a teacher-centred or student-centred approach’ (ibid: 75). According to Chall (ibid:74) these research studies have found that ‘hands-on’ activity-based teaching is of ‘secondary importance’ particularly for children of lower socioeconomic status and those with learning difficulties.

Whilst Chall (2000) acknowledges the argument that standard paper-and-pencil achievement tests may not be fair tests for learner-centred approaches and may be inadequate for measuring ‘thinking skills’, ‘problem solving’, ‘understanding’ and ‘creativity’, she points out that ‘when scores on standardized tests have been compared with teachers’ judgments and other qualitative measures, the correlations have been positive and quite high’ (ibid: 12).

Chall refers to research on the effectiveness of teacher-centred or learner-centred approaches that shows 'that facts and skills are both necessary', particularly at earlier school levels, 'for the meaningful development of higher-level cognitive skills' and 'effective problem-solving' to take place at higher school levels (Rosenshine & Meister, 1994 in Chall, 2000: 85).

In other words, her review suggests that higher level cognitive skills and the ability to learn new knowledge 'always require domain-specific knowledge' (Hirsch, 1999: 12). Chall (2000) also points to 'considerable research' that 'has found academic achievement in the early school years to predict later academic achievement' as well as to more recent research that has shown that school achievement is 'related to subsequent work productivity and to income' (Murnane & Levy, 1996 in Chall, 2000: 12).

In another study Smerdon *et al.* (1999: 29) found that learner-centred approaches are more time consuming because activities 'take a lot of time if students are to learn from them'. 'Students can be led down many blind alleys before they discover a good solution to a difficult problem. Feeling free to experiment means being allowed to make lots of mistakes without being chastised for being "wrong"' (ibid). What can be inferred from this study and studies reviewed by Rosenshine & Berliner is that the flexible time frames and notions of learner autonomy of learner-centred approaches may work against thorough subject matter coverage, the conceptual advancement of specialized skills and concepts, as well as coherence in domain-specific or disciplinary knowledge, in other words, 'Opportunity-to-Learn'.

Certainly research findings such as those cited by Chall (2000), and Rosenshine & Berliner (1978) suggest that for the average or less able learner, as opposed to the highly talented or very able learner, direct teaching and 'drill and practice' methods, particularly at early school levels, although less pleasant for both teacher and learners, may be far more efficient and cost-effective particularly for societies where the social justice goal is for 'quick gains' in equality in achievement outcomes.

Other studies in developed country contexts, on the other hand, indicate that learner-centred approaches to teaching *do* in fact result in increased learner attainment (Resnick, 1990; Maher 1991; Sigurdson & Olson, 1992; Keedy & Drmacich, 1994, Silver, Smith & Nelson, 1995, Boaler, 1997). For example, in the 1980s a meta-analysis by Athappilly *et al.* (1983:

491) of 134 controlled-outcome studies comparing progressive and traditional mathematics teaching found that 'the average person receiving some form of modern mathematics treatment is 0.24 standard deviation in achievement and 0.12 standard deviation in attitude above an average student not receiving modern mathematics'.

However, Lubienski (2001) argues that a closer examination of the instructional approaches used in programs or by teachers in developed country contexts who claim to use more 'open' learner-centred methods that 'work' with working class learners in terms of equity-based outcomes, reveals that approaches have been adapted to include strong forms of 'direct instruction' by teachers (ibid: 9). She asserts that the adaptations described generally endorse the view that working class learners are likely to gain the most from pedagogical practices where teachers make explicit the concepts, skills or procedures required to manipulate symbols.

Lubienski (2001) discusses studies in the USA such as Project SEED (Phillips & Ebrahim, 1993 in Lubienski, 2001: 8) which claims to use 'group discovery' to help low-SES learners 'learn abstract mathematics in order to promote the study of more advanced mathematics later'. Learners on this program 'do not explore open problems independently' ... 'instead the teacher leads the entire class through the exploration, using focusing questions' (ibid: 9). Learners 'do not discuss ideas with each other', instead they 'offer guesses to the teacher who tells the class if the guess is right or wrong' (ibid). 'The teacher requires students to constantly use hand signals indicating their agreement or disagreement with proposed ideas, which allows the teacher to motivate and continually assess students' participation. Finally, the problems being explored are not contextualized – abstract ideas are taught in the abstract' (ibid).

In fact, in the USA and elsewhere, indications are that the polemic debates about the effectiveness of learner-centred and teacher-centred approaches for reducing inequalities in outcomes are beginning to converge. Researchers are no longer dealing with them in crude oppositional terms but are considering that elements of 'traditional' and 'progressive' pedagogy should be 'mixed'. For example, Newman & Associates (1996) at the University of Wisconsin, Center on the Organisation and Restructuring of Schools (CORS) coined the term 'authentic pedagogies' to describe different elements of pedagogy that contributed to improved achievement (University of Queensland, School of Education, 2001: 20). Key

components of their conception of progressive pedagogy are 'deep knowledge' and 'deep understanding', 'substantive conversation' and 'higher order thinking' (ibid: 5). In Australia the *School Reform Longitudinal Study* (University of Queensland, School of Education, 2001) draws on CORS findings and instruments to develop the conception 'productive pedagogy', dimensions of which are 'high degrees of *intellectual quality*, high levels of demonstrable *relevance*, highly *supportive classroom environments*, and strong *recognition of difference*' (ibid: 6 – their italics). Indicators of a supportive classroom environment' included 'student control; 'engagement'; 'explicit criteria'; and 'self-regulation' (ibid: 4).

The shift is largely because there is growing recognition that, because learning is cumulative, further learning requires the use of 'core knowledge tools' learned at earlier school levels (Hirsch, 1999). The use of knowledge tools requires the ability to manipulate symbols. Learning skills at manipulating symbols, particularly at primary school level, is seen as a way of attaining greater equality by laying the basis for further learning and as crucial to future educational achievement. The idea is that the ability to manipulate symbols does not merely mean 'producing the correct answers'. Learners need to have procedural knowledge and know '*how to carry out computations*' as well as have 'conceptual understanding of *why the methods work*' (Lubienski, 2001: 10 - her italics), that is, understanding of the underlying knowledge principles.¹⁵

In mathematics education, for example, 'learner-centered' teaching methods may be inadequate for the purpose of achieving greater equality in outcomes that provide access to further learning to the extent that teachers may leave 'it entirely to learners to discover for themselves', for example, 'how computational procedures could be derived from the basic structure of the number and numeration system' (Resnick, 1982: 136). 'Even when basic concepts are quite well understood' because the focus has been on 'concepts *instead of procedures*', concepts 'may remain unrelated to computational procedures' and difficulties in

¹⁵ In mathematics learners may, for example, master 'the syntactic constraints of written subtraction without connecting them to the semantic information that underlies the algorithm' (Resnick, 1982: 138).

Written subtraction can be analysed as an algorithm defined by a set of *syntactic* rules that prescribe how problems should be written, an order in which certain operations must be performed, and which kinds of symbols belong in which positions. Although the syntax may reflect an underlying *semantics*, or meaning, an algorithm need not include any explicit reference to the semantics in order to be successfully performed (ibid: 137).

further learning may be 'a result of failure to understand the concepts on which procedures are based' (ibid – their italics).¹⁶

'Teacher-centered' approaches, on the other hand, may be inadequate to the extent that they can focus on producing the correct results through mathematical procedures without understanding of the underlying knowledge principles, an approach which undermines 'real learning' or increased ability in knowledge tool use. Still, developing the ability to manipulate symbols *does* require practice through repetition, and practice in symbolic manipulation through repetition may either be driven through the 'drill and practice' methods found in teacher-centred pedagogy or through repeated exposure in creative contexts as is advocated by learner-centred approaches.¹⁷

In other words, the argument is that both approaches may lead to increased ability in knowledge tool use, and it may be possible to improve the quality of learning outcomes and achieve equality in outcomes that provide access to further learning by using elements of either approach. Later on in Chapter 3, I report on research which further unpacks this notion of a 'mixed' pedagogy (for example, Morais & Neves, 2001, Morais, Neves & Pires, 2002) when I elaborate on a more theoretical and conceptual approach to characterizing 'type of pedagogy' than the ideologically polarized 'either teacher-centred or learner-centred' approach to pedagogy evident in South African curriculum documents and debates around pedagogy in developed country contexts.

2. PROBLEM STATEMENT AND OVERALL POLICY AIM

This study recognises the need to identify the policy variables most likely to assist populations of schools serving high poverty communities to 'deliver quality' in classrooms as measured through achievement outcomes. Although we do not know what the most effective policy approach to improving achievement in classrooms with learners from socio-

¹⁶ The implication is it is not enough to promote conceptual understanding as a goal for all learners because procedural knowledge is also important.

¹⁷ However, Nesher (1982:26) in a discussion about the teaching of addition and subtraction identifies a dispute around whether teachers should 'start with numbers and their symbolic operation' and then proceed 'with the applications of these operations to situations in the real world' or whether they should start with applications of addition and subtraction. She argues that this:

... dispute is not one of concrete versus abstract, as both approaches employ concrete materials for exemplification, but rather an epistemological dispute, which dictates different starting points in the acquisition of mathematics in general, and addition and subtraction in particular. Different answers not only lead to different approaches concerning the beginning steps, but also illustrate that this is a complicated question that has plurality of aspects, each of which should be studied in order to comprehend the entire phenomenon (ibid).

economically disadvantaged backgrounds is, South Africa has concentrated on pedagogy and largely ignored OTL. It seems that a policy priority in the country is for more larger-scale empirical studies that make it possible to identify those variables most likely to assist populations of schools serving high poverty communities to 'deliver quality' in classroom so that models of teaching and learning can be developed that affect learner achievement across socio-economic class.

The **policy problem** identified for this study is whether, in a cash-strapped developing country such as South Africa where the social goal is rapid redress and equity, ensuring high opportunity to learn specialized school knowledge or the promotion of a particular type of pedagogy is the more effective approach to improving the quality of outcomes in classrooms with low SES learners. The decision to study OTL and 'type of pedagogy' takes into consideration efforts in the post-apartheid era to improve educational quality and the need to identify policy variables that have the potential to narrow the class and race-related achievement gap; the changing landscape of South African curriculum policy; the prevailing pedagogical policy in the country; the poor research base on classroom factors that effect achievement in South Africa; and international research findings on classroom factors that effect learner achievement.

Given South Africa's apartheid past, the idea of investigative and 'flexible' approaches which encourage learners 'to move away from being directed and validated by authority figures' (Lubienski, 2001: 10) is intuitively and ideologically appealing. Furthermore, as Muller (1998: 188) concedes, creativity, initiative, reflexivity and autonomy are all generic dispositions and competencies increasingly valued in the global workplace. However, if OTL is independently important for the goal of greater equality in achievement outcomes and, as some research suggests, certain forms of learner-centred pedagogy are associated with reduced OTL, any attempt to achieve equity in outcomes by promoting forms of learner-centred pedagogy could pose considerable risks for the country given the current context. Taking into account the weak conceptual frames of teachers (Taylor & Vinjevold, 1999a, Ball & Bass, 2000), the amount of school time lost during the year (Crouch & Mabogoane, 1998; Schollar, 1995; Bateson, 1994), budgetary constraints, and, in particular, the extent of race and SES-based inequalities in academic outcomes (Howie & Hughes, 1998; Joint Education Trust, 2000 & 2001; NDoE, 2002c; Cape Argus, 26 May 2004), not only may learner-centred pedagogical forms not be able to deliver on increased equality in outcomes in

South Africa, but the promotion of these pedagogical forms may actually widen the gap between lower- and higher SES learners leading to even poorer outcomes in measures of equality for low SES learners.

On the other hand, if measures of OTL are found to be more useful policy variables and, as some research suggests, learners from socio-economically disadvantaged backgrounds who are exposed to low levels of OTL achieve less in measures of achievement than learners who are exposed to high levels of OTL irrespective of the primary pedagogy used, then it may still be possible to achieve equality in outcomes that provide access to further learning (prerequisites for a highly skilled labour force) whilst promoting creativity, initiative, reflexivity and autonomy (generic competencies and dispositions increasingly valued in the global workplace) (Muller, 1998) through learner-centred pedagogy as long as high levels of OTL are maintained. It may simply be that certain elements or combinations of elements of classroom pedagogical practices are independently related to enhancing low SES learners' access to specialised mathematics knowledge.

The policy question identified for this study is: Does research support or not support the existing South African policy and, if not, what should the model be?

By implication, the research model used for this study should make it possible to identify whether elements or combinations of elements of classroom practices and OTL enhance or diminish low SES learners' access to school knowledge. In other words, the design needs to make it possible to test the relative dependence or independence of different dimensions of the two focus constructs.

3. RESEARCH AIM

The dominant explanation in large scale educational research studies internationally is that OTL has a powerful effect on learner achievement (Husen, 1974 in Schmidt & McKnight, 1995; Schmidt *et al.*, 1997a; Shavelson *et al.*, 1989; Burstein, 1993; Porter & Smithson, 2001). However, as stated previously, in South Africa we have little information on the effects of OTL. The numerous small scale case studies that have been conducted have not really been concerned with the curricular content made available to learners. They have mainly paid attention to pedagogy (Taylor & Vinjevold, 1999a).

Most of these studies have focused on the socio-affective or regulative discourse and whether or not learners are exposed to the pedagogical approaches believed to promote the dispositions and competencies that are valued rather than on the development of specialized knowledge and understanding. The few larger scale statistical studies that have been carried out or the available large-data sets that have been analysed by sociologists, economists and statisticians such as Crouch & Mabogoane (2001) and Fedderke *et al.* (1998) have included input data on educational resources but rarely include descriptive data on classroom processes (in Seekings, 2001b; Taylor *et al.*, 2003).

Unlike most other larger-scale studies conducted in South Africa, this study investigates specific processes at the classroom level that may impact on achievement. In particular, the study aims to establish whether the OTL research findings from international studies and large scale studies within developed countries are sustained in the South African context. In accordance with the international evidence, the expectation of the study is that OTL will have a greater effect on achievement than ‘type of pedagogy’.

The **research hypothesis** is: OTL influences achievement outcomes in schools serving low SES communities more than ‘type of pedagogy’.

The **research aim** is to assess the relative effects of ‘Opportunity-to-Learn’ and ‘type of pedagogy’ on the achievement of learners from low SES backgrounds. The aim is to try to explain differential mathematics achievement amongst low SES learners by:

- i) investigating whether there is a relationship between the mathematics achievement of socio-economically disadvantaged learners and
 - a) ‘Opportunity-to-Learn’ (the specialized mathematics content made available to learners in the classroom); and
 - b) ‘Type of pedagogy’ (a ‘learner-centred’ form of classroom pedagogy);
- ii) establishing which of either of the two constructs are more strongly associated with achievement; and
- iii) therefore might be a more worthy policy variable to pursue in a cash-strapped country like South Africa where steady progress is a social justice imperative.

Research questions the study hopes to answer are:

- i) whether OTL or ‘type of pedagogy’ overall has more influence on achievement?

- ii) whether combinations of aspects of OTL and pedagogy (separately and together) have more influence on achievement?
- iii) which family background factors interact with OTL or pedagogy in relation to achievement? (See Chapter 4)

The intention is to compare the relative influence of ‘Opportunity-to-Learn’ and ‘type of pedagogy’ on achievement in a more sophisticated way that will allow me to disaggregate the effects of both dimensions of the teaching and learning process. As OTL may not be the only dimension of the process that shows effects on achievement, the study will also investigate interactions between the two focus constructs.

The empirical work takes the form of a medium-scale study conducted across one school year (2003). The study is designed to compare

- the quantity and quality of curricular content made available to a sample of low socio-economic status (SES) grade 6 learners;
- learners’ exposure to particular forms of pedagogy; and
- learner achievement gains.

In order to compare these aspects, the **research approach** is to

- 1) develop an analytical and theoretical framework for the study;
- 2) develop a language of description;
- 3) create data collection instruments drawing on the literature review in Chapter 2 and the analytical and theoretical framework outlined in Chapter 3;
- 4) systematically collect data on a sample of one thousand and one low socio-economic status (SES) grade 6 learners in thirty-eight classroom in twenty four schools in four Cape Peninsula districts. Data includes: before and after achievement data; individual level learner background data on variables that, according to international literature and available evidence from South African research, ‘can exercise direct effects on’ achievement (Rowan, 2002: 23); data on four key dimensions of OTL; and ‘type of pedagogy’ data on the instructional and regulative context in lessons.
- 5) analyse data using statistical modeling;
- 6) draw conclusions based on the findings.

The school subject chosen for the study is mathematics. This is because the verticality of its knowledge structure and its strong conceptual grammar makes it easier to explicate the rules of sequencing and pacing of curricular content within and across various grades for the school subject. These features make it relatively 'easier to conceptualize and measure' OTL (Floden, 2003: 232) than it is for other school subjects such as arts which do not have such strict verticality (Bernstein, 2000). Because mathematics is regarded as a 'gateway subject'¹⁸ (Chisholm *et al.*, 2000) and because its distinctive features make it easier to generalize findings for other gateway subjects, such as natural sciences, which also draw on relatively vertical knowledge structures with 'strong grammars' (Bernstein, 2000) in relation to key OTL variables, the subject is important in terms of research. By implication, a **limitation of the study** is that findings might not hold for subjects which draw on more horizontal knowledge structures (Muller, 2004a). This feature is discussed more fully in Chapter 3.

The study focuses on grade 6 because a degree of formalization of mathematics knowledge should take place during the Intermediate Phase (grades 4-6) if learners are to succeed in the long term when faced with the increasing complexities of the mathematics curriculum in the Senior Phase. By implication, what happens in the classroom during this period becomes critical especially for low SES learners who are unlikely to acquire formal school mathematics knowledge outside of school. Grade 6 has also been identified as a pivotal benchmark in learner performance by the National Department of Education.

4. OUTLINE OF CONTENTS

This thesis has been structured in the following way:

Chapter One of the study introduces the policy problem to be investigated. The intention is to investigate an assumption evident in South African curriculum policy documents that making available a particular form of pedagogy rather than the opportunity to learn content is the more effective approach to achieving greater equality in achievement outcomes for low SES learners. The Chapter provides a rationale for the study by outlining the policy need to establish whether the achievement of learners from socio-economically disadvantaged

¹⁸ A particular concern of the study is 'the issue of socio-economic equity' (Lubienski, 2001: 3) and, as Lubienski points out 'achievement in school mathematics can make a powerful impact on a student's future' (ibid: 7), because educational attainment in mathematics 'is used to "sort" students into careers' (ibid: 9).

backgrounds vary according to differences in opportunity to learn curriculum content or ‘type of pedagogy’. The chapter identifies the research aim and questions.

Chapter Two provides a literature review of the empirical construct ‘Opportunity-to-Learn’ as a research concept and elaborates on its use for establishing comparable data on the content of teaching and learning (the *what*) across classrooms. The chapter examines methodologies for measuring OTL, identifies key OTL variables associated with learner achievement and describes the methods most commonly used for the collection of OTL data.

Chapter Three provides a more theoretical and conceptual framework for the study derived from the work of the British social theorist Basil Bernstein (1971-2000). The chapter outlines how Bernstein’s model of pedagogical discourse provides an analytical framework that separates pedagogical practices at the micro level of the classroom (the *how*) from the curriculum made available to learners at the macro level of the academic school years (the *what*). His key concepts of classification and framing provide a common internal language of description for discussing OTL and ‘type of pedagogy’.

Chapter Four describes the research methods for this medium-scale study. Methods entail identifying appropriate quantitative measures of achievement and establishing mechanisms for calculating comparable quantifiable descriptions of ‘Opportunity-to-Learn’ and ‘type of pedagogy’. The chapter describes the mechanisms that made it possible to use statistical procedures to reflect the relationship between differences in gains in learner achievement (between test scores) and levels of exposure to mathematics content; and differences in achievement gains and levels of exposure to particular forms of pedagogy. Although the objective of the study is to investigate the two focal areas that education policy makers can influence, the chapter also discusses the collection of data on selective individual level background characteristics so as to control for their effect on achievement. Chapter four outlines the target variables, data sources, time of data collection, the instruments used in data gathering, and data analysis procedures which include regression techniques and hierarchical linear modeling.

Chapter Five provides descriptive results for the four key dimensions of the OTL construct – ‘content coverage by cognitive demand’, ‘content exposure’, ‘curricular coherence’, and ‘curricular pacing’. As a second step, the chapter presents a statistical analysis where the

objective is to investigate the relationship between the mathematics achievement gain and the explanatory variables for OTL through regression analysis. The chapter provides results from the first of a series of four regression models, modeling predictor variables of OTL to discover which, if any, of the measures are significantly related to achievement gain. Relationships between the pre- and post test scores or overall achievement status, and 'content coverage' in grade 5 and 6 are also explored.

Chapter Six outlines the development of a more empirically-based framework for analysing 'type of pedagogy' that draws on Bernstein's theoretical model. The chapter then provides a descriptive analysis of 'types of pedagogy' for the sample of learners and identifies the most prevalent pedagogical characteristics or practices evident. The second half of the chapter provides statistical results from the second of the series of four regression models, namely, modeling predictor variables of 'type of pedagogy', to discover whether 'type of pedagogy' or particular elements of pedagogy are significantly related to achievement gain.

The first part of **Chapter Seven** provides the third of the series of four regression models to see if any selective individual learner background variables are significantly related to achievement gain so that these can be included in the final model for the regression analysis. The second part of the chapter presents the results of the statistical model combining all the OTL, 'type of pedagogy' and individual learner background variables that came out as significant for achievement gain in the three previous models. The intention is to identify the relative effects of the significant OTL, classroom pedagogy and learner background level variables on achievement gain to see which variables contribute the most to increases or decreases in gain. In the third part of the chapter, the results of the regression modeling are compared with the results of hierarchical linear modeling (HLM) to see whether the results differ when data is modeled at two levels – one dealing with within-class data, or variables relating to individual learners, and the other with between-class data, or variables relating to each class.

In **Chapter Eight** the study's findings are used to draw conclusions about the factors identified in the statistical data exploration and modeling that appear to influence achievement for the sample of learners. The chapter discusses the implications of the findings for policy and derives policy recommendations. It concludes with a discussion of the methodological lessons learnt.

Chapter 2

LITERATURE REVIEW: 'OPPORTUNITY-TO-LEARN'

In the introduction, I outlined how one of the primary concerns of the study is to establish

- a) differential levels of exposure of OTL; and
- b) whether there is a relationship between differential levels of OTL and differential levels of achievement gains amongst low SES South African learners.

Section 1 of this chapter reviews the use of the OTL concept as an empirical research construct. The main purpose of the review is to:

- provide a working hypothesis as to which dimensions of OTL are expected to have effects on achievement in the South African context;
- compile possible OTL variables and data collection methods for the study; and
- identify an appropriate methodology for studying OTL in the South African context.

1. OTL: AN EMPIRICAL RESEARCH CONSTRUCT

In section 1.3.1 of Chapter 1, I identified key dimensions of OTL associated with learner achievement in large-scale international studies and studies within developed countries. Amount of exposure to curricular content dimensions of OTL (Wang, 1998: 140) are 'content coverage by cognitive level', 'content emphasis', and 'content exposure'.

- 'Content coverage by cognitive demand' refers to the cognitive or conceptual level at which the contents were covered at the macro level of the school year/s (Husen, 1967 in Pelgrum, 1989; Gamoran, Porter, Smithson & White, 1997 in Floden 2003; Thompson & Senk, 2001; Porter & Smithson, 2001; Schmidt *et al.*, 2001) whilst 'content emphasis' refers to the relative amount of time spent on the various contents.
- 'Content exposure' refers to the amount of time spent engaged with the academic content (Carroll, 1963; Rosenshine & Berliner, 1978; Berliner *et al.*, 1978 in Floden, 2003; Lee; 1982; McDonnell *et al.*, 1990 in Wang, 1998; Porter & Smithson, 2001; Schmidt *et al.*, 2001)

Quality of exposure to curricular content dimensions (Wang, 1998: 140) are 'curricular coherence' and 'curricular pacing'.

- 'Curricular coherence' refers to 'grade-level coherence' and measures the degree of coherence in the sequencing of curricular content over the school year/s (Smith, Smith & Bryk, 1998; Rose, 2002)
- 'Curricular pacing' refers to the 'curriculum pacing trajectory' across grades at a school. This dimension of OTL measures whether curricular content progresses at an appropriate level from grade to grade within a school. It reflects whether there is conceptual advancement of specialized skills and concepts across grades so that learners have the pre-requisite content knowledge for the next year. The idea is that 'curricular pacing' reduces the likelihood of cumulative knowledge deficits amongst learners (Smith, Smith & Bryk, 1998; Rose, 2002).

In section 1.1, I review how these OTL dimensions have been measured in research studies. The aim is to identify key variables for an operational concept of OTL that could be used to establish differences in levels of OTL in the South African context (see the methodology chapter, Chapter 4).

1.1. Amount of exposure to curricular content OTL variables

1.1.1 'Content coverage by cognitive demand'

Content coverage

The first dimension of OTL evident in the literature is 'content coverage' (Stevens, 1996). Husen (1967 in Pelgrum, 1989) appears to be 'the first researcher' to use the 'content coverage' OTL dimension in the IEA's FIMS to measure whether particular content had been taught prior to testing (Pelgrum, 1989: 19).

Rowan (2002: 16) observes 'any serious attempt to measure content coverage' or 'what should be learnt', has to begin 'with a basic categorization of curriculum in a particular subject area (for example, maths). For example, mathematics content on instruments is usually 'organised along the lines of algebra, geometry, measurement, etc.' (Porter & Smithson, 2001:73). 'Such categorization schemes have been derived from many different sources, including curriculum frameworks or standards documents, textbooks, and items included in the achievement test(s) being used as the dependent variable(s)' (Rowan, 2002: 16). The most common method of specifying elements of a curriculum is through 'the hierarchical classification' of content categories 'that represent topic areas for a certain

subject' (Bloom, Hastings & Madaus, 1982 in Pelgrum, 1989: 16) 'using nested subcategories of increasing specificity' (Schmidt *et al.*, 1996: 204) as was done with the Third International Maths and Science Study curriculum frameworks. The TIMSS mathematics frameworks comprise '10 major *content* categories each with 1 to 17 sub-categories' (ibid). Five of the sub-categories for the main category 'Numbers' are 'Whole numbers'; 'Fractions and decimals'; 'Integer, rational, and real numbers'; 'Other numbers and number concepts'; and 'Estimation and number sense' (ibid: 205).

However, an added difficulty of collecting data on 'content coverage' is establishing the content complexity or difficulty level at which the contents are taught and whether the work covered corresponds to or is higher or lower than the expected level for the grade. In frameworks such as the TIMSS the 'grain size', or 'level of specificity for each aspect's categories – is the same throughout the frameworks' (Schmidt *et al.*, 1996: 204). For example, the sub-category 'Whole numbers' does not specify whether coverage involved 3-, 6-, or 9-digit whole numbers. Rowan (2002: 16) warns that very course-grained descriptions of instructional content may contribute to 'unreliability in measurement'.

With this in mind, Porter and Smithson (2001: 65) developed 'Surveys of the Enacted Curriculum' (SEC) instruments as tools for collecting data. Their approach entailed making important decisions about issues such as 'grain size' (ibid: 79). According to them the first challenge was breaking the content up into 'the right topics' (ibid). They further observed that 'a function of the analytic capacity of the language' used in the instrument was 'to describe not only what is taught and with what relative emphasis, but also what is not taught' (ibid: 73). Porter & Smithson (ibid: 73) specify that the grain size or level of detail of the description of the content must be appropriate – 'too much or too little detail presents problems.'

In the South African context what makes it even more difficult to try to establish categories of 'content coverage' is that the curriculum-in use at the time of my study, the 1997 version of Curriculum 2005 (NDeO, 1997b,c & d), does not express the core content, skills and concepts learners are expected cover in the numeracy and mathematics Learning Area in each grade. The outcome 'Demonstrate ways of working with numbers', for example, does not specify grade level requirements. However, the mathematics Learning Area Statements in the RNCS documents (2002b) do list minimum assessment standards per outcome per grade.

The assessment standards provide a guide to the content, concepts and skills that are considered essential for school mathematics for each grade in each phase. They could thus be used to construct a framework of potential curriculum content, as I will show in Chapter 4.

Cognitive demand

A second dimension of ‘content coverage’, besides the content complexity dimension, is the ‘cognitive level’ at which the contents are covered. This assesses whether the cognitive demands of the work taught are high or low in terms of intellectual processes. For example, in the TIMSS frameworks, this dimension was called ‘performance expectations’. The five main categories for this in the mathematics frameworks were ‘Knowing’; ‘Using routine procedures’; ‘Investigating and problem-solving’; ‘mathematical reasoning’; and ‘Communicating’ (Schmidt *et al.*, 1996: 207). Porter & Smithson (2001: 74) state that ‘getting the right cognitive demand’ and deciding on ‘how many distinctions of cognitive demand should be made’ and ‘how they should be defined’ is crucial.

Porter & Smithson (2001: 75) go on to review ‘performance goals’ described in a number of mathematics instruments citing distinctions ranging from three – ‘conceptual understanding’, ‘skills’, and ‘applications’ to ten in a National Center of Education Statistics instrument (*ibid*: 75). The nine distinctions used in the *Reform Up Close* instrument include ‘memorise facts/definitions/equations; understand concepts; collect data (e.g. observe, measure); order, compare, estimate, approximate; perform procedures – execute algorithms/routine procedures (including factoring, classify); solve routine problems, replicate proofs; interpret data, recognise patterns; recognise, formulate, and solve novel problems/design experiments; and build and revise theory/develop proofs. Another distinction of cognitive demand used in a study reviewed is - skills (procedures), properties (‘the principles behind the mathematics’ and ‘represent the reasoning expectations of mathematics’), uses (‘applications of mathematics in real situations’) and representations (pictures, graphs or objects) (Thompson & Senk, 2001: 64). Gamoran, Porter, Smithson, & White (1997 in Floden, 2003: 243) defined cognitive demands according to six levels: (1) memorize facts; (2) understand concepts, (3) perform procedures/solve equations, (4) collect/interpret data, (5) solve word problems, and (6) solve novel problems.

However, it is not always possible to distinguish an obvious hierarchy between the categories of cognitive demand used by researchers. For example, there is arguably no real hierarchy

between 'collecting or interpreting data' and 'solving word problems', or between uses ('applications of mathematics in real situations') and representations (pictures, graphs or objects). It is also possible for learners to be engaged in word problems at procedural levels without engaging with underlying knowledge principles.

Gamoran, Porter, Smithson & White (1997 in Floden 2003) found the combination of topics and cognitive demand showed the highest correlations with achievement. For Porter & Smithson (2001: 74) 'topic by cognitive demand' is the best 'grain of distinction.' Content or topic complexity is considered to form an important dimension of cognitive demand since engagement with more complex content is more demanding than engagement involving simpler content and increases the complexity of a task (Stodolsky 1988 in MacFarland, 2001: 641). In Porter & Smithson's research, for example, measures of the attained curriculum (tests) used were 'content analysed', 'item-by-item', in a sub-study 'using the same language and distinctions for designing content (topics by cognitive demand) as employed in the "Survey of the Enacted Curriculum" instrument. For each test, the average degree of emphasis on a topic (e.g., linear equations) by cognitive demand (e.g., solve novel problems) intersection, across content analysers, was calculated' (Porter & Smithson, 2001: 68). The result was 'a matrix of proportions', with topic-by-cognitive demand dimensions. The researchers state that the advantage of this method is that it allowed for 'instruction-to-assessment alignment'. An 'alignment variable' was calculated from comparable descriptions of the content of instruction by cognitive demand and the assessment items used (ibid).

In South Africa, curriculum documents do not specify the cognitive levels at which learners are expected to engage with mathematics. The RNCS (NDeO, 2002b) and Draft number 2 of the Mathematics Learning Programme Policy Guidelines/MLPPG (NDeO, nd: p.2.4 & 2.5) do, however, express the expectation that learners will be engaged with procedural knowledge as well as with underlying mathematical principles and concepts. Thus, the categories of cognitive demand that appear most relevant in our context are 'procedures' and 'properties' or 'the principles behind the mathematics'. In Chapter 4, I will select content levels by cognitive levels for my study from the above review of categories bearing the context and purpose of the research in mind.

Content emphasis

An aspect of content coverage evident in the literature is 'content emphasis' (Stevens, 1996). This aspect refers to the emphasis given to or amount of time spent on the different contents and is usually used to show variation in how many lesson periods or minutes are devoted to particular topics or sub-topics. For example, in a study by McDonnell *et al.* (1990 in Wang, 1998: 140-1), teachers were asked to identify how many lesson periods were devoted to a particular topic as the measure of the 'content emphasis' information.

Other researchers argue that 'asking teachers how much *time* (their italics) they spent in teaching the content' is simply an 'operationalisation of the relative emphasis of the teaching' of a topic compared to the other topics (De Haan: 1992: 20). Hence other attributes that have been used to measure this dimension include whether the topic was treated as 'not important', 'slightly important'; 'quite important'; 'very important' or whether it was given 'no emphasis'; 'moderate emphasis'; 'a great deal of emphasis' (Rowan, 2002: 17). McDonnell *et al.*, 1990; National Center for Education Statistics, 1990; Schmidt, 1992; Shavelson & Stern, 1981 (in Wang, 1998: 141) asked teachers whether a certain area was treated as 'a major topic'; 'a minor topic', 'a review topic', or 'not taught at all.' The four OTL variables used to measure Test Curriculum Overlap (TCO) (when teachers examine tests to be administered to their students) in the Canadian Opportunity-to Learn instrument used in the IEA's Second International Science Study (SISS) are provided below (from De Haan, 1992: 20): (Coded values awarded are between brackets). Teachers were asked to answer the following:

Taught

When is the content of this item first taught to students in your school system?:

- A. before the current year (1)
- B. during the current year (1)
- C. after the current year (0)
- D. it varies among schools and programs of study (0)
- E. it is not taught at all (0)
- F. I don't know (missing)

Time

The amount of time you spend teaching your students the content they need to answer the item is:

- | | |
|--------------------------|-----------------------------------|
| A. None (0) | D. 31 min.-60 minutes (45) |
| B. 15 min. or less (7.5) | E. 61 minutes – 180 minutes (120) |
| C. 16-30 min. (22.5) | F. more than 180 minutes (240) |

Level

How does the conceptual level of the item compare to the level at which you teach the content:

- | | |
|---------------------------|--|
| A. lower than taught (-1) | C. higher than taught (1) |
| B. about the same (0) | D. I don't teach the content (missing) |

Importance

In terms of your objectives for this course, the content of the item is:

- | | |
|---------------------------|------------------------|
| A. not important (0) | C. quite important (1) |
| B. slightly important (0) | D. very important (1) |

Porter & Smithson's SEC instrument similarly required teachers to report on the amount of emphasis placed on each 'content alternative'. They assert that 'the ideal metric' for measuring 'content emphasis' is time: 'how many instructional minutes were allocated to a particular type of content?' (Porter & Smithson, 2001: 77).

In South Africa, neither the 1997 version of Curriculum 2005 (NDeO, 1997b, c & d) nor the RNCS for mathematics (NDeO, 2002b) provide indications as to how much time teachers should ideally devote to certain mathematics topics. Expert opinion would have to be sought to gain an ideal notion of the amount of time teacher could be expected to spend on different topics.

1.1.2 'Content exposure'

In her review of key OTL variables, Stevens (1996) identifies a second significant time-related dimension of OTL – 'content exposure'. According to Stevens, 'content exposure' describes whether teachers organise time on task and keep learners 'on task' so that there is enough time for thorough teaching of topics, concepts or skills (Brophy & Good, 1986; Wiley, 1990; Winfield, 1987 in Stevens, 1996: 2). In general, data on this 'content exposure' dimension show variation in how allocated time is actually used in class and how learners spend learning time or time on task. John Carroll's (1963) 'model of school learning' has been identified as a possible source for this dimension of OTL. Carroll formulated a conceptual learning model that introduced the importance of opportunity to learn as 'time on learning' (Wang, 1998: 137).

In contrast to the early 1960s IEA studies, Carroll's model defined OTL 'as the actual time available to individual students to learn' (Wang, 1998: 140). 'Spending time' means

'actually spending time on the act of learning' – that is time on task. It is 'the time during which the person is oriented to the learning task and actively engaged in learning' ... "it is the time during which he (sic) is "paying attention" and "trying to learn"" (Carroll, 1963: 725). One of the implicit assumptions is that it is individual teachers who determine how allocated time for learning gets used in the classroom and that 'the degree of learning, other things being equal, is a simple function of the amount of time during which the pupil engages actively in learning' (ibid: 732).

In the 1970s, the Beginning Teacher Evaluation Study (BTES), (Berliner, Fisher, Filby & Marliave, 1978 in Floden, 2003: 235) found that time spent by individual teachers was associated with learner achievement but that, when they added information about learner engagement, they obtained 'an even stronger connection' (ibid).

Following the work of Bloom (1976), Berliner and his colleagues argued that student achievement would be more accurately predicted by shifting from allocated time to 'engaged' time. That is students are more likely to learn if they not only have time that is supposed to be devoted to learning content, but also are paying attention during that time, if they are 'engaged'. Pushing the conception even further, they argued that the student should not only be engaged, but should be engaged in some task that is relevant to the content to be learned. That is, the opportunity that counts is one in which the student is paying attention, and paying attention to material related to the intended learning (Floden, 2003: 235).

Lee (1982) in *Exploring the Construct of 'Opportunity to Learn'* describes a sub-study of the Sustaining Effects Study using a sub-sample of 55 schools with the highest concentration of economically disadvantaged students. In this study the OTL construct 'consisted of three components: time, curriculum overlap, and on-task behavior. "Time" refers to the amount of instructional time students were present for instruction in the subject. Measures included the average number of instructional minutes per day. "On-task behavior" refers to the absolute amount of time that students were present and engaged in learning in class that is relevant to the subject area. Measures of "on-task" activities were those directly related to the acquisition of subject-matter knowledge' (ibid: 62). One of the main findings of the sub-study was that 'the more days of school between the pre-test and post-test, the better children perform on achievement tests' (ibid: 63). In other words, Lee's findings supported the belief

that, 'content exposure' defined as more time devoted to teaching a subject area, increased on-task behavior and academically engaged time in class raises achievement.

In Australia the School Reform Longitudinal Study (SRLS) (University of Queensland, School of Education, 2001: 14) identified 'disengagement' 'by off-task behaviours which signal boredom or a lack of effort by students; these include day dreaming, talking to peers about non-class matters, or otherwise disrupting the class'. 'Conversely, engagement is identified by on-task behaviours which signal a serious investment in class work. These signals include attentiveness, doing the assigned work, and showing enthusiasm for this work by taking initiative to raise questions, contributing to group tasks and helping peers' (ibid). In the study learner engagement was 'judged both in terms of the temporal consistency of engagement (for how long, for how much of the lesson are students engaged), and in terms of how many students display engagement (a few students, small groups, all)' (Anderson, 1994 in University of Queensland, School of Education, 2001: 14).

In South Africa the amount of teaching time lost during the year is of concern (Fleisch, 1999; Reeves, 2001; Taylor, 2001). Although the length of the South African academic school year is comparable to that of other countries, researchers have reported that considerable time is lost to teaching in many schools. For example, through a late start to the school day, late registration of learners at the beginning of the year, and through non-instructional activities such as staff meetings, staff training, marking test or examination scripts, extra-curricular sporting or cultural activities, school celebrations and memorial services taking place during official teaching time (Taylor and Vinjevold, 1999a). Officially allocated teaching time would thus not be considered a reliable measure of the total amount of time devoted to mathematics instruction. Rather, internal measures of the time actually spent and levels of engagement in class are crucial.

1.2 Quality of exposure to curricular content OTL variables

In Time and Opportunity to Learn in Pakistan's schools: some lessons on the links between research and policy Reimers (1993: 5) reports on a study that examined 'the effect on student achievement of teacher and student absences, time of contact with teachers, time allocated to teach the subject (mathematics and science), and the relationship between time allocated and coverage of the curriculum' in a developing country. The study examined 'the contribution of time to student achievement using data from a national sample survey in Pakistan' (ibid).

In contrast to Lee's findings, this study showed that 'teaching time by itself is a poor predictor of student achievement' (Reimer, 1993: 7). The evidence was that 'teachers can spend long hours with the students without significant gains in achievement, while teachers spending less time with their students can have higher levels of learning in their classes' (ibid). The study concluded that policy intervention for developing countries needs to go beyond 'setting and maintaining standards for teaching time' (ibid). 'Improving teacher effectiveness' calls 'more for strategies to help teachers make productive use of the time they have available rather than for expansion of that time' (ibid).

Reimers (1993: 7) stresses 'that an understanding of opportunity to learn' in developing country contexts such as Pakistan may need 'to move beyond teaching time to understanding why is there such a loose link between the coverage of the curriculum and teaching time or why some teachers make better use of the time they have available than others.' He suggests that 'when the quality of an education system is very low "more of the same" will not produce large learning gains for students' (ibid: 8). He concludes that expanding opportunities for learners to learn in a 'weak' system must entail improving teachers' levels of subject knowledge and ensuring that learners are more effectively engaged with the knowledge to be learnt (ibid).

In line with Reimer's findings, a variable that is also receiving attention in teacher education and research in South Africa and elsewhere, and that is believed to be linked to improving the quality of learners' exposure to content, is teachers' knowledge base, in particular teachers' 'subject matter knowledge' and 'conceptual knowledge' (Taylor and Vinjevoold, 1999), 'epistemological knowledge' (Steinbring, 1998), as well as their 'subject knowledge for teaching' (Usiskin, 2000; Adler *et al.*, 2002) and 'Pedagogic Content Knowledge' (PCK)¹⁹ (Shulman, 1986: 87; Cochran, King & DeRuiter, 1991; Aubrey, 1997; Veal, Tippins & Bell, 1998; Veal & Makinster, 1999; Ball & Bass, 2000).

¹⁹ Shulman (1986) used the construct PCK to differentiate between a subject teacher and a content specialist. Although a strong content background is seen as a central in pedagogical content knowledge, this form of knowledge is seen as unique to teachers as it entails knowledge of how to structure and represent academic content; knowledge of common misconceptions and difficulties that learners encounter when learning particular content; as well as knowledge of the specific teaching strategies for addressing learner needs in particular contexts. PCK is viewed 'as a set of special attributes that help someone transfer the knowledge of content to others' (Geddis, 1993 in Veal & Makinster, 1999: 3). Shulman (1986:15) argued that

The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students.

The idea is that teachers with these knowledge forms are able to 'teach right' by integrating the curricula, classroom activities and textbooks into coherent lessons. However, although teachers' knowledge base may influence the quality of learners' exposure to content, input variables such as PCK and 'subject knowledge for teaching' alone do not provide measures of the curriculum that is actually made available to learners in the classroom or of the coherence of what is made available. Teachers may know their content well, have conceptual knowledge and PCK, but the actual process of providing learners with opportunity to learn coherent domain-specific knowledge may not necessarily be enacted in classrooms because of teacher absenteeism or disruptions at schools.

Rather, the review of OTL as a research construct points to a large body of research that has suggested that Opportunity-to-Learn is defined not just in terms of the curricular content made available to learners (McDonnell, 1995: 309) but also to the internal organization and structure of the content made available. The idea is that curricular content needs to be presented to learners in ways that are logically and sequentially connected ('curricular coherence') and that learners may learn better if subjects and topics are presented in a coherent manner over the school years ('curricular pacing').

1.2.1 'Curricular pacing'

Of relevance here is research in the USA described in *Setting the Pace: Opportunities to Learn in Chicago Public Elementary Schools*, Smith, Smith & Bryk (1998). The study arose out of the fact that classroom observations had revealed that similar lessons and concepts were being taught 'again and again' to learners several grades apart 'with no development in depth and complexity' (website abstract) so that learners' 'classroom life' consisted 'of repetitive cycles of basic skills instruction' (Smith, Smith & Bryk, 1998: 22) as well as 'gaps in instruction' (ibid: 26). Together with a 'steady exposure to slow pacing' across grades, certain learners appeared to be left 'farther and farther behind' (ibid: 2).

A research study was developed to address the issue of curricular pacing 'on a system-wide level' where survey reports on the content teachers taught were used 'to examine the prevalence of slow or repetitive pacing and its distribution in Chicago schools' (website abstract). The focus of the study was on mathematics because it 'is commonly approached as

a systematic presentation of topics that builds upon prior knowledge' (ibid).²⁰ The 'accountability' question was 'Are students at each grade given the opportunity to learn the concepts for which they are held accountable on standardised tests?' Teacher survey questionnaires were used to establish actual topic coverage and level and the relative amount of time spent on each content area in each grade.

Reports from schools across various grades were then used to formulate 'two key indicators of each school's organisation of instruction' (Smith, Smith & Bryk, 1998: 19). One indicator was 'curricular pacing', that is 'the rate at which teachers in a school introduce new and more difficult subject matter to their students' (ibid: 20). Teachers' survey responses were used to check whether content coverage across adjacent grades at the school 'was consistent with (or above) grade level mastery' (ibid: 19) and to 'investigate how curricular content progresses from grade to grade' within a school (ibid: 9). Combined data from the survey responses of mathematics teachers across grades within a school was then used to compute 'a curriculum pacing trajectory' for that school (ibid: 12). A school's 'curriculum pacing trajectory' described 'the overall opportunity to learn afforded by a school as students pass through the elementary grades' (ibid: 25).

The study found 'curricular pacing' problems were 'most prevalent' in 'high poverty schools', predominantly minority and African-American schools, schools with 'high mobility' (ibid: 7). The researchers found that 'curriculum pacing was positively related to the school's achievement history' (ibid: 21) and that the gap between what is taught to students from different backgrounds revealed 'major differences in opportunities to learn'. However, the study also found that, whilst 'students in Chicago's most disadvantaged neighborhoods are much more likely to encounter instruction that is poorly coordinated and that conveys weak expectations for student learning', some schools that served disadvantaged communities were 'working to align their instructional programs across classrooms and grades' (ibid). Such schools presented their learners 'with a progression of challenging instructional opportunities' that 'keep pace with nationally normed expectations for student achievement' (ibid;7).

²⁰ As pointed out in Chapter 1, mathematics is a subject which draws on a relatively vertical knowledge structure with a strong grammar. In Chapter 4 I elaborate on how such subjects may well be idiosyncratic with respect to this.

Certainly in South Africa, where research evidence suggests high levels of under-preparedness and cumulative deficits in school knowledge amongst many low SES learners (Howie & Hughes, 1998, Joint Education Trust, 2000, & 2001; Ensor *et al.*, 2002), it appears that 'curricular pacing' is a concern for narrowing the gap in achievement outcomes between learners of different social backgrounds. For example, studies have shown that 'many Grade 6 learners are not able to perform mathematics and reading tasks expected at the Grade 3 level' (Joint Education Trust, 2001: 3). Also of relevance for the South African context where learner mobility is prevalent in schools serving poor communities (Hoadley, 1999; Seeking, 2001 – see footnote 4, Chapter 1) are the findings of a report from the US General Accounting Office that 'student mobility' or 'frequently-moving students' combined with poor pacing within and between schools 'contribute significantly to the low achievement' of the USA 'system as a whole' (Hirsch, 1999: 35).

1.2.2 'Curricular coherence'

In her review of OTL variables, Stevens (1996) identifies an 'instructional delivery' OTL variable which describes whether the presentation of the content is coherent, whether individual lessons have a beginning, middle and end and whether content is presented through a series of lessons and activities that are logically and sequentially connected. Stevens (nd: 8) points out that videotapes of lessons from the TIMSS 'revealed how important it is for teachers to plan and present coherent lessons'. 'Teachers can cover content, expose students to the curriculum, and emphasise or focus on certain agreed on topics within the curriculum but the power of these OTL variables are diluted when lessons are presented that are incoherent and thus ineffective' (ibid: 9).

In their investigation of mathematics and science teaching in six of the countries that participated in TIMSS, Schmidt *et al.* (1996: 28-29) similarly refer to the logic and coherence with which 'topics or sub-topics are sequenced and developed' both within lessons and in terms of the enacted curriculum. In their analysis of TIMSS data on the mathematics curriculum standards, Schmidt, Houang & Cogan (2002) observed that the standards of the highest performing countries articulated the logical and sequential nature of the disciplinary content from which they were derived.

Factors in Carroll's learning model (1963) that affect learner achievement included a 'quality of instruction' dimension defined as the organisation and presentation of 'the task to be

learned in such a way that the learner can learn it as rapidly and as efficiently as he (sic) is able' (Carroll, 1963: 726). According to Carroll's model 'the various aspects of the learning task must be presented in such an order and with such detail that, as far as possible, every step of the learning is adequately prepared for by a previous step.' Carroll (ibid: 726/7) asserts that 'if the quality of instruction is anything less than optimal, it is possible that the learner will need more time to learn the task than he would otherwise need.' The underlying notion of all of the above is that curricular content needs to be presented to learners in ways that are logically and sequentially connected.

Indeed the second indicator of the quality of a school's structure and organization of curriculum developed for Smith, Smith & Bryk's (1998) study was 'grade-level instructional coherence', or the coordination of curricular content within each school grade. For them the concern was, 'Is there a distinctive fifth-grade curriculum, or does each fifth-grade teacher "do her own thing"' (ibid: 12). In their study, teachers' content coverage and emphasis reports were used to compute 'a measure of similarity' or high or low 'overlap' or variability in maths content coverage' among teachers of the same grade level (ibid).

In South Africa empirical research suggests that, because Curriculum 2005 training has 'encouraged team planning for the new curriculum' (Joint Education Trust, 2000: 22), the current trend is for grade level teachers, particularly in schools with low SES learners, to develop and use the same, often integrated or thematic, teaching schemes or plans. Thus, unlike schools in the USA where curricular differentiation occurs through 'track placement'²¹ or 'streaming' (McDonnell: 1996), there is little evidence that schools use differentiated curricula within grades. A measure of 'curricular coherence' or within grade developmental complexity more relevant to the South African context, is the degree to which curricular content is logically and sequentially presented to learners within a particular grade in terms of its organization across the academic year.

In the following section I review the data collection methods most commonly used for the four dimensions of the OTL constructs so as to consider methods for the study in Chapter 4.

²¹ Learners are placed in different streams depending on their academic abilities and vocational goal.

1.3 OTL data collection methods

By far the most common method for collecting data on OTL, particularly in large-scale studies, is self-report survey questionnaires administered to teachers. Porter and Smithson (2001) make a strong case for using a survey approach to data collection in large-scale studies, rather than, for example, lesson observations, simply because of cost and feasibility. They argue that 'since the period of instruction is long' and 'since content changes from week to week if not day to day', a sample of lesson observation or lesson videos is not an appropriate method of data collection (ibid:76). For them the critical issue in survey questionnaires is 'how to get a response metric as close to the ideal as possible and still have a task that respondents find manageable and that they can use with accuracy' (ibid: 77).

Teacher survey approaches to OTL data collection have been criticized on the grounds that self-report data raises validity questions as teachers might give 'socially desirable' answers (McDonnell, 1995: 307). Secondly, although 'teachers in some studies fill out these surveys on a daily basis', in most studies, 'they fill out an instrument once annually, near the end of the year' (Rowan: 2002, 16). This 'one shot' approach can contribute towards 'unreliability in measurement' because 'teachers are expected to accurately recall their content coverage patterns across an entire year' (ibid: 18). The argument is that 'this lack of accuracy probably introduces substantial error' ... 'biasing all effect sizes downwards and perhaps preventing us from discovering statistically significant relationships' (ibid: 16) and points to the 'advantages of gathering information about OTL at various points in time' rather than 'once off' (Floden, 2003: 250).

Other methods that have been used for measuring OTL, besides survey approaches and getting teachers or other subject experts to examine actual test items, as: examining teacher logs or record books (Porter, 1993 in Stevens, nd: 2) and adapting the teacher log approach using Web-based technology (Ball *et al.*, 1999 in Floden, 2003), direct lesson observations (Stevenson & Stigler, 1992, Stevens, 1993 in Stevens, nd: 2) although this is not usually used in large-scale studies; and learner surveys (Goertz, 1994 in Stevens, nd: 2). For example, the BTES Berliner (Fisher, Filby & Marliave, 1978 in Floden, 2003) used a combination of teacher logs and classroom observations to estimate how much time a sample of primary school teachers spent on various maths topics and 'the fraction of allocated time that students actually engaged in the learning opportunities' (Floden, 2003: 258).

In their review of measures of OTL used in studies on the 'relationship between content covered and student achievement gain', Rosenshine & Berliner (1978: 5) list 'counting the number of pages of the common textbook covered during the semester' (Good, Grouws & Beckerman, in press); 'counting the number of words which the teacher attempted to teach' (Beez, 1968; Carter, 1969; Brown, 1969; Barr, 1973); 'counting the amount of mathematics problems covered' (McDonald, 1975); and 'coding the level of the workbook the students completed just before they took a post-test' (Rosenhine, 1976). Reimers (1993: 5) also mentions examining teacher and learner absences and comparing time allocated to teach with actual contact time with teachers.

In the South African context self-report data alone is not generally considered sufficiently trustworthy. For example, the PEI report (Taylor & Vinjevoold, 1999a) reported that studies showed disparities between what teachers actually did in terms of classroom practices, and what they said they did in their classrooms (see for example, Pile & Smith, 1998; Baxen & Green, 1998 in Taylor & Vinjevoold, 1999a). We have little knowledge of levels of agreement between teachers' and researchers' reports of information on the content of instruction.

Section 1.4 reviews the main methodologies for measuring Opportunity-to-Learn so as to establish a possible methodology for measuring OTL in the South African context.

1.4 OTL Methodologies

The literature review revealed that OTL methodologies depend largely on the purposes of the research (McDonnell, 1995). Three main methodologies are distinguishable in the literature. These relate to the use of OTL:

- in international comparative studies;
- in national educational systems;
- as a policy accountability tool.

1.4.1 OTL in international comparative studies

The purpose of most large-scale cross-country studies such as the TIMSS is to determine and investigate variation in learner performance across countries so as to compare education systems. In particular, comparative international studies provide opportunities for researchers to investigate practices and inputs that might explain the huge variances between the average

science and maths achievement in ‘top-performing countries’²² and the average achievement in other ‘lower performing countries’, or, in countries where learner performance was ranked below the international average (Schmidt *et al.*, 1997b). As discussed in Chapter 1, the IEA’s FIMS, SIMS and TIMSS have consistently shown that TCO²³ certainly in mathematics and science is a ‘consistent predictor of student achievement scores’ (Rowan, 2002: 16).

In IEA cross country studies, the ‘traditional’ model of OTL used assumes various factors influence educational opportunity at three different levels represented by three conceptions of curriculum – the curriculum as planned or intended at the system level, the curriculum as taught, implemented or enacted at the classroom level, and the curriculum as learned, achieved, attained, or realised at the learner level (Schmidt *et al.*, 1996: 16). The First International Mathematics Survey (FIMS) in the 1960s raised questions about discrepancies in content coverage among participating countries in the intended and implemented curriculum and the content tested (the attained curriculum).

The construct ‘Opportunity-to Learn’ was subsequently coined as a technical concept designed to ensure valid cross-national comparisons (McDonnell, 1995). In the Second International Mathematics Study (SIMS) conducted between 1976 and 1982, the measurement strategy for OTL entailed having teachers examine tests to be administered to their students and report whether or not the learners had had the opportunity to learn the knowledge necessary to complete the tests satisfactorily²⁴ (Schmidt *et al.*, 1997a: 175).

The IEA index for OTL was ‘the percentage of teachers in a country reporting that students have been given adequate opportunity to learn the knowledge needed to answer specific test items’ (Schmidt *et al.*, 1997a: 175). Thus OTL was a percentage measure of the availability of various topics in the implemented curriculum (Travers & Westbury, 1989). ‘Because the major purpose of the OTL measure in the SIMS was to ensure valid comparisons across

²² ‘Top-performing’ countries in the TIMSS included Singapore, Japan, and Korea, where results nationally showed greater equality in outcomes (Schmidt *et al.*, 2001).

²³ Curriculum overlap refers to the extent to which the content of the curriculum matches the content of the achievement tests.

²⁴ A problem with this approach is that teachers may conflate OTL information ‘with information about student’s familiarity with specific features of a test item that are either irrelevant or tangential to the mathematics topic’ (Floden, 2003: 241). Schmidt & McKnight (1996: 344) also point out, that the main difficulty of this conception of OTL lies, ‘not in its success’, but in its conception ‘as a surrogate for national curriculum’ and what it ‘does and does not indicate’. Pelgrum (1989: 23) further adds that ‘unfairness may come about because the implemented curriculum is measured by a finite set of test items. Thus, teachers may cover a lot of subject matter in their teaching of a particular domain, but his (sic) subject matter might not be adequately represented by the set of items used to measure the implemented curriculum.’

countries, test items were purposely selected to have maximum and approximately equal validity in all national and provincial systems included in the sample' (McDonnell, 1995: 307).

In cross-national studies where the intended curriculum in each country varies, OTL is used mainly to determine that the general ability or standardized tests used are not biased in favour of learners in countries with the greatest TCO (Schmidt *et al.*, 1996).

1.4.2 OTL indicators in national educational systems

McDonnell (1995: 309) observes that until the mid 1980s the type of data routinely collected about 'conditions of schooling' in most developed countries 'had focused historically on inputs such as per-pupil spending and on outcomes, most notably student test scores'. In the mid 80s information about school and classroom practices and processes and 'the way in which educational inputs were used' increasingly began to be seen as 'as important as the absolute level of those resources' (*ibid*). Until the mid 80s this type of information 'tended to be available only through research studies that were based on data collected from limited samples on a non-routine basis' (*ibid*).

As Floden (2003: 253/254) elaborates, Husen's 1967 report on FIMS considered OTL as a control variable that was 'given' rather than a curriculum variable that could be changed. However, after the SIMS, OTL began to be seen as a policy relevant curriculum variable within countries that was useful for national curriculum planning. OTL began to be used as a research indicator for monitoring the 'health' of a number of national, provincial, regional, or state education systems and curriculum reform programmes (McDonnell, 1996).

It seems though that, through this process, the concept of OTL gradually began to expand beyond its 'primary focus on topic coverage' (*ibid*) to include, and in some cases become conflated with, a variety of other process indicators such as whether learners were exposed to particular teaching methods and input data such as teacher experience and qualifications and educational resources (Guiton & Oakes, 1995: 325). The methodology appears to have shifted the OTL research focus from its original curricular focus and the identification of key OTL variables associated with learner achievement to more general equity concerns not necessarily shown to be related to achievement.

1.4.3 OTL as a policy accountability tool

In the 1990s, OTL began to emerge as a policy 'accountability' tool, particularly through notions of OTL Standards in the USA, that is, standards that 'define a set of conditions that schools, districts, and states must meet in order to ensure students an equal opportunity to meet expectations for their performance' in 'high stakes' tests (Elmore & Fuhrman, 1995: 1). This 'accountability' conception of OTL is based on 'a belief that students should not be assessed on knowledge that they had not been given an opportunity to learn' (McDonnell, 1996: 306).²⁵ The conception is largely based on the idea that such 'high stakes' learner assessment should be based on the curricular content actually made available to learners in the implemented curriculum before tests are administered.

In line with the traditional model of OTL, a research concern here is obtaining 'a Fair Test' measure by ensuring that items are fair to all learners because all learners have the opportunity to learn the content tested. However, the main research intention in this conception is predominantly about 'equalising' OTL and the primary concern is whether all learners are actually being taught a curriculum that will prepare them for the high stakes assessments. For example, in the USA a particular concern is how curricular differentiation through 'track placement' or 'streaming' within a single system influences learner performance. The OTL research focus is on schools' structuring and organization of curriculum and collecting information that could be used to hold schools and teachers accountable for learner achievement as measured by standardised tests (McDonnell, 1996: 309).

In national, provincial, regional, or state 'accountability contexts' where the curriculum does not vary and the intention is constant, the methodology for measuring OTL has shifted to a focus on measuring alignment between the intended, the implemented curriculum and measures of the achieved curriculum (Porter & Smithson: 2001: 61). For example, in their report on studies measuring the impact of US policy Content Standards on OTL received, Porter & Smithson (*ibid*) emphasise the need for 'procedures for measuring alignment'

²⁵ When high stakes test are administered, OTL is mainly based on the idea that assessment should be based on the curricular knowledge actually made available to learners in the implemented curriculum. However, the literature review also showed that a great deal of the current OTL Standards debate in the USA focuses on pedagogy. As in South Africa, discussion revolves around whether all learners are exposed to the teaching methods believed to promote the development of higher level critical thinking skills such as co-operative learning through group work and real world problem solving. There is also an argument that Standards should include teaching practices as well as outcomes. Input data on teacher experience and qualifications and the 'uneven distribution of educational resources' (Guiton & Oakes, 1995: 325) also form part of the Standards debate in the USA.

between the desired 'target' and the enacted curriculum. They argue that ideally the 'target' identified should be the intended curriculum as reflected in policy tools such as content standards, curriculum frameworks and guidelines.

This conception recognizes that the main problem with using assessments to describe the 'target' is that 'any particular form of assessment will necessarily represent only a sample of items from the domain of interest' (Porter & Smithson: 2001: 65). Although assessments 'are intended to convey the same content message' as the intended curriculum, they 'are not prescriptive in the sense of defining well what *should* (their italics) be taught' (ibid: 64). Thus besides using procedures of alignment between the intended and enacted curriculum, this 'accountability' methodology includes the use of procedures for measuring alignment between the enacted curriculum and the achieved curriculum as measured through assessments (ibid: 63).

1.4.4 An OTL methodology in the South African context

In 2003, when data collection for this PhD study was conducted, schools in South Africa were implementing the 'un-reviewed' Curriculum 2005, which, as has already been pointed out, does not specify what minimal content learners are expected to learn in each grade. Teachers were not yet covering an agreed upon common core of skills, concepts and content at each grade level specific to each Learning Area.

Until grade 6 mathematics teachers are officially implementing the RNCS, an OTL methodology in the South African context cannot be used to assess whether schools are meeting content standards as set out in the intended curriculum. When I carried out the empirical data collection for this study, the OTL methodology could not be applied in order to obtain a measure of 'fairness' by determining whether all learners actually had the opportunity to learn the same content. Neither could the OTL construct be employed as an accountability tool with the intention of 'passing judgment' on how close the content in the implemented curriculum is to the content in the intended curriculum. However, it could be used to establish variations in the content of instruction and whether or not there is a relationship between differential levels of OTL in the implemented curriculum and differential levels of achievement through the use of pre- and post-tests. It could be used as a proximate baseline against which to assess achievement.

2. RESUME OF THIS CHAPTER

The purpose of this study is to try to explain differential mathematics achievement amongst low SES learners by

- i) investigating whether there is a relationship between the mathematics achievement of socio-economically disadvantaged learners and
‘Opportunity-to-Learn’ (the specialized mathematics content made available to learners in the classroom); and
‘Type of pedagogy’ (a particular form of classroom pedagogy);
- ii) establishing which of either of the two constructs are more strongly associated with achievement; and
- iii) therefore might be more worthwhile policy variables to pursue.

The working hypothesis derived from the OTL literature review is that the following four dimensions of the OTL construct will have effects on the achievement outcomes:

- Content coverage by cognitive demand;
- Content exposure;
- Curricular pacing; and
- Curricular coherence.

Like most other OTL studies, the research will include multidimensional measures of OTL. As explained in section 1.4, the purpose of the study acts as a guide for selection a methodology. Table 2 summarises key variables for each dimension of the OTL construct found to have an empirical relationship with achievement or achievement gain and key methods used for collecting data in the research reviewed. The research methods summarized are those that seem most useful for the research purpose.

Table 2: Key OTL variables and data collection methods

OTL dimension	Variables	Main data collection methods
'Content by cognitive demand'	Coverage of curriculum topics and sub-topics. Relative emphasis given or estimated amount of time spent on each topic/sub-topic covered. Cognitive level at which the topics/sub-topics are covered.	Teacher or learner self-report survey questionnaires (may involve getting teachers to examine actual test items). Examining teachers' log books. Analysing the content and level of the textbooks used.
'Content exposure'	Absolute amount of time spent on mathematics. Amount of time that teachers/learners are present. 'Academically engaged time' or the extent to which learners are academically engaged in mathematics tasks or in paying attention.	Counting the amount of pages or problems covered. Counting the numbers of days of teacher and learner absences. Comparing allocated time with actual contact time. Direct lesson observation.
'Curricular coherence'	Coherence of the sequencing of the topics/sub-topics made available.	Teacher or learner self-report survey questionnaires. Examining teachers' log books.
'Curricular pacing'	Pacing of curriculum content across adjacent grades in terms of developmental complexity.	Teacher or learner self-report survey questionnaires. Examining teachers' log books.

In Chapter 4, I will select variables and methods using the above summary with the purpose of the research in mind. Before I discuss this and the construction of instruments in Chapter 4, I will first outline a theoretical basis for discussing pedagogy and for discussing OTL in a more analytical way in Chapter 3.

Whilst the research construct 'Opportunity-to-Learn' is useful for establishing comparable descriptions of the curriculum made available to learners, the construct is based on a number of factors drawn from available empirical evidence and has no underlying theoretical or explanatory framework for the empirical phenomena observed. It has common-sense, or face, validity, but there is no particular conceptual rationale for why OTL indicators consistently conceived in this particular way are any more plausible than those conceived in other more pedagogical terms. Chapter 3 proceeds to take into account more theoretical considerations for the study. An analytical framework will be constructed that allows for the separation of information on OTL and information about teaching practices so that the influences of each on achievement outcomes can be investigated and discussed using a common internal language of description. The theoretical basis will make it possible to discuss OTL and pedagogy within the same analytical framework.

Chapter 3

THEORETICAL AND CONCEPTUAL FRAMEWORK

As discussed in Chapter 1, in South Africa, a learner-centred pedagogy is believed to be linked to the quality of learning outcomes. In large-scale educational research studies internationally the dominant explanation is that OTL that has a more powerful effect on learner achievement (Husen, 1974 in Schmidt & McKnight, 1995; Schmidt *et al.*, 1997a; Shavelson *et al.*, 1989; Burstein, 1993; Porter & Smithson: 2001).

In Chapter 2, I elaborated on the OTL indicators that show effects on achievement empirically. However, both the OTL indicators and the 'either teacher-centred or learner-centred' debates around pedagogy evident in the international literature and in South African curriculum policy documents are essentially atheoretical. In this chapter I try to provide a more theoretical and conceptual framework for my empirical study so that I can make theoretical as well as empirical generalisations. The framework is derived from the work of the British social theorist Basil Bernstein (1971-2000).

Other cultural reproduction theorists besides Bernstein, for example, Bowles & Gintis (1976), Bourdieu & Passeron (1977) and Bourdieu (1986, 1988), 'provide explanations for the fact that schools not only reflect, but re-inforce the class disparities in society, despite the best intentions of educators' (Boaler, nd: 3). However, I found only Bernstein's work sufficiently robust to be operationalised for my particular empirical research:

- His model of pedagogical discourse (see section 1 of this chapter) provides an internal language of description²⁶ and a methodological model (see section 2) that allows me to locate the OTL construct in a model of pedagogy (see section 2.1), and separate pedagogical practices at the micro level of the classroom from the curriculum made available to learners at the macro level of the academic school years (see section 5).

²⁶ According to Bernstein, 2000:

Briefly, a language of description is a translation device whereby one language is transformed into another. We can distinguish between internal and external languages of description...A language of description constructs what is to count as an empirical referent, how such referents related to each other to produce a specific text and translate these referential relations into theoretical objects or potential theoretical objects. In other words the external language of description (L^2) is the means by which the internal language (L^1) is activated as a reading device or vice versa (ibid:132 and 133).

- His concepts of classification and framing (see section 1.3) provide a common internal language of description for discussing OTL and ‘type of pedagogy’.
- His analysis of the internal features of discursive forms and knowledge structures and concepts of classification and framing are useful for explaining the strong association between the empirical construct OTL and mathematics and science achievement evident in international studies (see section 1.4).
- His distinction between visible and invisible pedagogies (see section 1.5) and competence and performance modalities (see section 1.6) and concepts of classification and framing provide a more conceptual syntax for characterizing ‘type of pedagogy’ than the ideologically polarized ‘either teacher-centred or learner-centred’ model of pedagogy evident in South African curriculum documents and debates around pedagogy in developed country contexts.
- His theoretical predictions provide strong guidance for relating differences in OTL to the creation of educational inequality as well as about what ‘type of pedagogy’ may be more or less effective for learners from lower SES backgrounds (see section 3).
- His theoretical framework is useful for analyzing the structure of Curriculum 2005 and the RNCS so as to develop an appropriate methodology for studying variations in OTL in the South African context (see section 4).

In section 1 of this chapter I elaborate on Bernstein’s model of pedagogical discourse, his concepts of classification and framing and his distinction between

- vertical and horizontal discourse and knowledge structures;
- visible and invisible pedagogies or forms of transmission; and
- competence and performance modalities.

1. BERNSTEIN’S MODEL OF PEDAGOGY

1.1 The rules of pedagogic discourse

For Bernstein (1990: 64-65) any pedagogic situation always consists of transmitters and acquirers where ‘the acquirer has to learn to be an acquirer and the transmitter has to learn to be a transmitter’. Bernstein stresses that although ‘there may be various strategies for disguising, “masking”, or “hiding” the asymmetry or inequality of the power or authority relationship between teachers and learners, the pedagogic relationship is by necessity and intrinsically an unequal relation’(ibid: 65).

As Davis (2002: 3) points out, this is because the transmitter or teacher is the 'subject-supposed-to-know' and the acquirer or learner is the 'subject-not-supposed-to-know' – 'the former is, supposedly, on the side of knowledge; and the latter, on the side of ignorance'. Dowling (1999: 12) elaborates that if the acquirer 'already possesses the principles of evaluation' ... 'that would not be a pedagogic situation because it would entail no transmission'.

1.1.1 Criterial rules, sequencing rules and hierarchical rules

According to Bernstein (1996), there are three rules that any pedagogic situation must have. These are

- criterial rules,
- sequencing/pacing rules, and
- hierarchical rules.

Bernstein emphasizes that 'any specific pedagogic practice is there for one purpose: to transmit *criteria*' for evaluation (1996: 43 – his emphasis). At the heart of any pedagogic relationship is the evaluation of the levels of competence of the learner. However, because transmission of the criteria for evaluation 'cannot always happen at once', 'something must come before and something must come after' and 'if there is a progression, there must be sequencing rules, and these sequencing rules will imply pacing rules. Pacing is the rate of expected acquisition of the sequencing rules, that is, how much you are expected to learn in a given amount of time. The third set of rules in pedagogic practice, the hierarchical rules, are rules of 'conduct, character, and manner' (Bernstein, 2000: 13).

1.2 Instructional and regulative discourse

For Bernstein (1990: 183) pedagogic discourse comprises 'the rules for embedding and relating two discourses', instructional and regulative. In formal education, **instructional discourse (ID)** refers to the transmission or acquisition of curricular knowledge and skills, whilst **regulative discourse (RD)** is concerned with 'the transmission of principles of social order, relation and identity' (ibid: 211).

The rules of instructional discourse or what Bernstein terms 'discursive rules' relate to selection, sequencing, pacing and the criteria for evaluation. The rules of regulative

discourse relate to the rules of the social order or control over the social base. This socio-affective or regulative discourse is ‘the dominant discourse’ because it is the precondition for any instructional discourse which is always embedded within regulative discourse (Bernstein, 2000: 34). In section 1.6, I elaborate on this aspect. Table 3 summarises the model of pedagogic discourse thus far.

Table 3: Bernstein’s model of pedagogic discourse

ID (Discursive relations and discursive rules comprising criterial rules and selection, sequencing and pacing rules)
RD (Hierarchical relations and hierarchical rules)

Both dimensions of pedagogic discourse can be described in terms of classification and framing.

1.3 Classification and framing

Bernstein (1975) uses the term ‘classification’ (C) to ‘refer to the degree of boundary maintenance between contents’ or ‘the degree of insulation between categories of discourse, agents, practices, contexts’ or spaces (ibid: 88). Such boundaries mark what counts as valid, correct or appropriate. For example, in schools ‘classification relates to the organisation of knowledge into *curricula*, or the various domains of educational activity’ (Atkinson, 1985: 133 - his emphasis). Dowling (2002: 3) describes classification ‘as a measure of the extent to which categories – for example, curriculum subjects – are structurally distinct’.

Classification can be strong (C+) or weak (C-). ‘Where we have strong classification, the rule is: things must be kept apart. Where we have weak classification, the rule is: things must be brought together’ (Bernstein, 2000: 11). Classification relations reflect power relations. Classification rules are related to the distribution of power and ‘between-context relationships’ (ibid: 181). For example, ‘the principle of classification regulates *what* discourse is to be transmitted, and its relation to other discourses in a given set (e.g. a curriculum)’ (ibid: 99).

Bernstein (1975) postulated a second important concept ‘framing’ (F) for analyzing the organization and structure of pedagogical discourse. Framing rules relate to the principle of

control and are 'about *who* controls *what*' (Bernstein, 2000: 12). They reflect 'within-context practice' (ibid: 181). 'With strong framing (F+) control lies with the teacher, whereas with weak framing (F-) control lies apparently with the student' within the classroom (ibid: 99). 'The principle of framing regulates *how* the discourse is to be transmitted and acquired in the pedagogical context' (ibid).

Bernstein's two principles of classification and framing make it possible to characterise the different elements of pedagogical discourse in terms of strong/weak classification or framing. The values of classification and framing can vary independently of each other with respect to elements of pedagogical discourse. Equally it is possible 'for framing of the instructional discourse to be different from the framing of regulative discourse' (Bernstein, 2000: 102). The strengths of framing 'can vary between instructional and regulative discourse' (ibid: 13). For example, as I will show later, it is possible to have strong framing over hierarchical rules 'but degrees of implicitness of sequential/pacing rules, which indicate a weakening in the framing of these rules' (Bernstein, 1990: 89). 'You could have weak framing over pacing but strong framing over other aspects of the discourse' such as selection, sequencing and evaluation (Ivinson, 2002: 2).

1.3.1 External and internal classification and framing

Bernstein's concepts of classification and framing also have 'internal and external features' (C^e/C^i and F^e/F^i) (Bernstein, 2000). ⁱ refers to internal control *within* a context and ^e refers to external control *between* contexts (ibid: 187). For example, at the policy level, *external* framing over the discursive rules in the intended curriculum indicates the degree of control schools or teachers, as opposed to the 'system', possess over the selection, sequencing and pacing of the knowledge transmitted and received. Where the distributive rules regulating the selection, pacing and sequencing of specialized discourses in the 'official' curriculum are strongly framed (F^e+), schools or teachers have less control over the curriculum they implement in terms of the selection, sequencing and pacing of content.

Where the distributive rules regulating the selection, pacing and sequencing of specialized discourses *across* grades are not explicitly specified in the policy documents, *external* framing is weak (F^e-). Under the circumstances, schools apparently have more control or freedom to exercise their discretion in terms of the curriculum they make available to their

learners in each grade. Where *external* framing at the school level is strong, the discretion or control of individual teachers over the implemented curriculum is similarly reduced.

Bernstein defines pedagogical discourse as 'a message system' that defines *both* 'what counts as a valid transmission of knowledge' (Atkinson, 1985: 136) and 'the rules of specialized communication through which' learners' identities 'are selectively created' (Bernstein, 1990: 183). In Section 1.6, I discuss the latter. In the following section, section 1.4, I discuss Bernstein's distinction between everyday and specialized discursive forms. Bernstein (2000) distinguishes between two discursive forms evident in all societies – horizontal discourse and vertical discourse.

1.4 Horizontal and vertical discourses

Horizontal discourse draws on everyday common sense knowledge and acts as a social and cultural relay for communities. This discourse is usually acquired at home either through oral communication or through tacit modeling. It is highly context dependent, is distributed segmentally, and has no overarching principles or knowledge structures relating or ordering different knowledge segments to one another. For example, how to clean ones teeth is essentially unrelated to learning how to tie ones shoelaces or how to answer the telephone. Common sense non-codified 'knowledges' are related not by integration of their meanings through some co-ordinating principle, but 'through the functional relations of segments or contexts to everyday life' (Bernstein, 2000: 158-9).

Vertical discourse, in contrast, is distributed through a recontextualising or re-interpretation principle and draws on specialized un-common sense knowledge which is generalisable across specific contexts. For instance, the discourse of the academic domain physics which has to be re-contextualised as the school subject, physical science. It is the re-contextualising principle of vertical discourses that systematically codifies or orders meaning making them hierarchically and conceptually coherent. As Atkinson (1985: 133) points out 'the principle that knowledge contents are subject to some selection and separation is clearly a prerequisite to anything recognizable as a curriculum. Without some such classification, the curriculum would be coterminous with the entire universe of possible knowledge and experience'.

Whilst access to such symbolic power through un-common sense knowledge forms is regulated by distributive rules (for example, sequencing and pacing rules) regulating who can

get what, when and how, horizontal common sense knowledge forms such as how to answer the telephone do not have a re-contextualising principle regulating access. In contrast, these everyday knowledge forms are distributed segmentally through distributive rules which regulate 'the circulation of knowledge, behaviour and expectation according to status/position' (Bernstein, 1995: 5). Knowledge potentially belongs to all in a community who have access to the discourse.

What is important is the principle that re-contextualisation codifies and separates or creates a boundary between curricular school knowledge of formal education and non-codified everyday knowledge. Vertical discourse forms a dimension of pedagogic discourse in formal school contexts. However, not all specialized school knowledge structures take the same form.

1.4.1 Vertical and horizontal knowledge structures

Some specialized knowledge structures such as mathematics and physics are hierarchically organized in terms of principles of conceptual coherence so that each level of meaning is conceptually related to the next level. Other vertical knowledge structures such as Social Sciences are organized around principles of connective coherence and take the form of a 'horizontal' series of specialized language (Bernstein, 2000: 163). Yet others such as crafts have weak grammars. This means that, although they have a re-contextualising principle regulating access, they are tacit and cannot easily be expressed in language. They thus more closely resemble 'everyday' horizontal discourses in that they are usually tacitly rather than explicitly transmitted, through modeling or demonstration (Bernstein, 2000).

The school subjects mathematics and natural sciences are, in Bernstein's terms, 'singulars' which draw on relatively vertical knowledge structures with strong grammars. These distinctive features make it easier for the conceptual structure or relations within the knowledge structure to be clearly explicated as far as codified curricular content is concerned (Bernstein, 2000). The strong conceptual grammar of mathematics and natural sciences makes their re-contextualisation from the academic domain as school subjects more amenable to expressing the distributive rules of sequencing and pacing for curricula across various grades than other subjects. For example, it is easier to formally articulate the conceptual ordering of curricular knowledge across grades for mathematics than it is for the Learning Area of Arts.

Bernstein's distinction between horizontal and vertical discursive forms and vertical and horizontal knowledge structures is useful for explaining in more theoretical terms why the strong association between curricular structure and learner achievement in international studies is most evident for mathematics and science achievement. It may be that the strong conceptual syntax of these school subjects that gives them the power or potential for optimising equity of opportunity-to-learn specialized skills and knowledge by making *visible* the rules regulating the sequencing and pacing of curriculum content across years of schooling through strong *external* framing. Explicit coherent conceptual structuring of curricular knowledge through the 'systematic presentation of topics that builds upon prior knowledge' (website abstract, Smith, Smith & Bryk, 1998) in the *intended curriculum* may act as an inclusionary mechanism for ensuring that high status mathematical knowledge and skills are made equally available to all learners. However, as suggested in Chapter 1, this verticality of their subject's knowledge structure may well differentiate them from other subjects with weaker knowledge structures (Muller, 2004a).

In section 1.5, I discuss how Bernstein's early work (1975) distinguishes between such 'visible' and 'invisible' principles of pedagogic discourse.

1.5 Visible and invisible pedagogies

In classrooms the principles underpinning pedagogic discourse are visible when the hierarchical relations between teacher and learners, 'the rules of organisation (sequence, pace) and the criteria' for evaluation are 'explicit and so known' to the learners (Bernstein, 2000: 109). Pedagogic principles, or 'the acts of teaching', are invisible when the hierarchical rules, the sequencing rules and criterial rules are 'implicit and so not known' to the learners (*ibid*). 'In the case of invisible pedagogy it is *as if* the pupil is the author of the practice and even the authority, whereas in the case of visible practices, *it is clearly* the teacher who is the author and authority' (Bernstein, 1996:112 – his italics). Strong values of classification and framing indicate a visible/explicit pedagogy whilst values of weak classification and framing indicate an invisible/implicit pedagogy. A shift from visible to invisible pedagogy will involve what *appears* to be a shift of control from the teacher to the learners (his emphasis).

In *invisible pedagogies* learning takes place through the exploration and discussion of 'integrative' problems and 'real world' contexts where the learner is expected to be self-

regulating, active, autonomous, and initiate, take responsibility for or control the organization, pacing and timing of learning. The regulative or social context is *apparently* relaxed and social hierarchy or positional authority of the teacher is de-emphasised or 'masked' so that the teacher as 'socialiser' 'is transformed into a *facilitator*' (Bernstein, 1975: 119 - his italics). The teacher's control in invisible pedagogy is implicit or covert and 'is a matter of negotiation and influence rather than power and status' (Atkinson, 1985: 150).

The criteria that will be evaluated in invisible pedagogy are not explicitly defined to the learner. Rather, multiple 'dimensions' of the learner's activities, interests and dispositions are open to assessment (Berlak, 1981: 137). As learners are 'expected to be constructively "busy"' (active), it is the 'quality of their "busyness"' (activity) that is evaluated (Walford, 1986: 191). In other words, the teacher's evaluative focus is on learners' 'supposedly innate' social and/academic competences rather than only on their written or textual performance (Rose, 2002: 1).

The regulative context in invisible pedagogy is based on implicit control through the potential of 'total surveillance' of the whole child as 'more of the learner's private world is on display' (Muller, 1998: 186). Basic to invisible pedagogy is the concept of 'learning through play' ('fun'), and it is thus that 'the unique doing of each child is facilitated' (Bernstein, 1975: 118). The 'spontaneity' of the learner 'is filtered' through the 'surveillance and then implicitly shaped according to interpretation, evaluation and diagnosis' (ibid). In invisible pedagogy performance is ungraded and 'based upon the progression of a person' not of a group (ibid: 13). 'Invisible pedagogies are less concerned to produce explicit stratifying differences' between learners 'because they are apparently less interested in matching the acquirer's text against an external common standard' (Bernstein, 1990: 71).

As sequencing rules or stages of progression are implicit and thus unknown to the learner who 'apparently has wide powers' or influence over what knowledge is selected (Bernstein, 1975: 116), 'progression is not facilitated by explicit public control' (ibid: 119). The social basis 'is not an individualized act, but a personalized act' (ibid: 118), and 'differences revealed by an invisible pedagogy are not to be used as a basis for comparison *between* acquirers, for differences reveal *uniqueness*' (Bernstein, 1990: 71 - his italics). Bernstein (ibid: 82) states that because academic statuses in invisible pedagogy 'are relatively more weakly marked, because of the more individualized or, better, personalized realisations

expected, the child, by apparently competing only with her/himself, competes with everybody' through criterion referencing (Bernstein, 2000: 13).

In 'opposition' to invisible pedagogies, **visible pedagogies** focus on 'states of knowledge and received problems' (Bernstein, 1975: 134) and 'intellectual and cognitive development' (Berlak, 1981: 137). The teacher explicitly controls and regulates the organization, pacing and timing of learning. The social basis of authority or control is positional rather than personal, that is, 'control is vested in the positions themselves' (Atkinson, 1985: 150) and the authority of the teacher is explicitly positional. The criteria for evaluation of learner's written texts are specific - the teacher gives learners 'formulas and procedures to follow' (Lubienski, 2004: 109). Expectations are clearly defined. The teacher makes learners 'aware of how to recognise and realise the legitimate text' (Bernstein, 2000: 60). The emphasis is on the academic *performance* of the child and the extent to which his/her 'external product' or textual performance is meeting the external criteria for evaluation (Bernstein, 1990: 70).

In this way, academic 'differences between children' are produced (Bernstein, 1990: 71) and learners are graded individually 'according to the levels at which their achievement meets explicit external criteria' (Edwards, 1991: 269). In visible pedagogies the sequencing rules or rules of progression are highly explicit and the learning horizon of the child is marked 'in very clear steps or stages' (Bernstein, 1990: 74). The teacher controls the selection of activities or materials, and, if a learner does not meet the requirements for each stage, he or she 'will fall further and further behind' (ibid). Thus the system of evaluation is likely to be standardised and 'the profile of the pupils may be obtained by looking across his (sic) grades' (Bernstein, 1975: 130).

According to Bernstein, invisible pedagogy is really the basis of child-centred 'progressive' pedagogy more commonly found in pre-schools. He notes that in general schooling one 'rarely finds a pure form of an invisible pedagogy but rather an embedded pedagogic practice where the invisible pedagogy is embedded in a visible pedagogy' (Bernstein, 1990: 84). He states that, 'even for ardent sponsors of invisible pedagogies, this practice is generally confined to the child's early years; certainly by the secondary level the demand is for a visible pedagogy, as it is this practice which leads to professional occupational placement' (ibid). Traditionally, in education systems, particularly at secondary level, teachers'

discretion is reduced through stronger *external* classification and framing over instructional discourse in the official curriculum.

In section 1.3.1, I said that Bernstein defines pedagogical discourse as ‘a message system’ that defines *both* ‘what counts as a valid transmission of knowledge’ (Atkinson, 1985: 136 – his italics) and ‘the rules of specialized communication through which’ learners’ identities ‘are selectively created’ (Bernstein, 1990: 183). In his later work Bernstein (1996 & 2000) further developed his notions of visible and invisible pedagogies by drawing a distinction between competence and performance modalities for identifying ‘the rules of specialized communication through which’ learners’ specialised identities ‘are selectively created’ through pedagogic discourse (Bernstein, 1990: 183).

1.6 Competence and performance modalities

The idea is that the conceptual instruments of classification and framing make it possible to identify ‘the dominant pedagogic code’ or socialising principle in classrooms (Bernstein, 1990: 43). ‘Any one set of values for classification and framing constitutes the modality of the code’ (ibid). Strong values of classification and framing in the classroom indicate a modality centred on the teacher and weak classification and framing indicate a modality centred on the learner. However, as stated in section 1.2, the social or regulative discourse is always ‘the dominant discourse’ (Bernstein, 2000: 34), and, one cannot ‘discuss what it means to acquire the identity of a learner of mathematics without considering both’ instructional and regulative discourse (Ensor *et al.*, 2002: 4). For example, in ‘mostly weakly classified and framed classes’ the emphasis is ‘on highly personalized control’ (Bernstein, 2000: 107).

For this reason a change of knowledge code entails a change in roles (Lubienski, 2001). For example, a shift from visible/performance to invisible/competence pedagogy is a change in code or regulative principle because it entails a change in the role of the teacher as explicit ‘rule-giver’ and the role of learners ‘in receiving explicit direction from the teacher’ (ibid: 6). Boaler, (n.d.: 21) submits a change in code encourages ‘different forms of preparedness for the problems students encounter in their jobs and everyday lives’. For example, Walford (1986) has used Bernstein’s theoretical framework to show how ‘a balance’ between pedagogical codes is apparently achieved in elite British public schooling (ibid: 187). He explains that, whilst the strong classification and framing of the curriculum in British public

schools provides learners with 'a high chance of entry' to further education, 'the archetypal professional occupation' that these learners are expected to occupy later is weakly classified and framed (ibid).

Professionals are 'expected to be creative and forward looking, to initiate and control rather than be controlled,' and the 'organisation, pacing and timing of the work are set by the professional rather than any superior'. Responsibilities 'are not firmly bounded, but expand as new initiatives occur' (ibid: 187). 'No strict line may be drawn between work and play. Work carries what is often called "intrinsic" satisfactions, and therefore is not confined to *one* context' (Bernstein, 1975: 118 – his italics). Walford (1986: 187) demonstrates how learners at these schools are allowed to 'experience elements of weaker classification and framing' of the invisible pedagogy mainly through extra-curricular activities and this enables them to 'experience the correct code for their future preferred occupations'. However, Walford emphasizes that, at such schools, this is never done at the expense of maintaining high chances of entry into further education.

Even where *external* classification and framing over the intended curriculum at the level of policy or even the school level is strong and the discretion of the teacher over instructional discourse is reduced, teachers can still make more degrees of freedom over the instructional and regulative context available to learners within their lessons. This is because there remains some space at the micro level of the classroom for teachers to expand learners' discretion in their pedagogy, for example, by weakening framing over micro pacing within their lessons. By implication, in performance curriculum models, where curricula are defined by content, teachers have more discretion over regulative discourse than they have over instructional discourse and can still include elements of invisible pedagogy in their classrooms.

Conversely, in competence curriculum models where curricula are defined by competencies or outcomes rather than content, *external* framing over instructional discourse (content) in curriculum documents is weakened whilst framing over regulative discourse is strengthened so as to promote dispositions such as creativity, reflexivity, self-regulation, autonomy, co-operation and inter-action with peers. Teachers' discretion over regulative discourse or the micro code in the classroom is thus reduced as they are expected to use approaches believed to promote these competencies. Nevertheless, as Bernstein (1990: 84) observes, in formal

schooling 'the specific specialized skills and attributes of a visible pedagogy are still beneath the surface' of competence models. The expectation underpinning the weak *external* classification and framing over instructional discourse is that schools and teachers will still ensure the specialisation of learners' pedagogic identities by making the necessary specialized knowledge available to them over their learning careers. This implicit macro code is the invisible dimension in competence or invisible models. In section 3.3, I will elaborate further on this.

Although Bernstein presents visible/ performance and invisible/ competence pedagogies as two 'idealised' types, he uses the terms as a heuristic device and 'as dialectically related oppositional forms' rather than as 'simple dichotomies' (Shalem, 2002: 1). In the classroom, one can expect 'to find a patterning of practice' which tends more towards one modality than the other (Ivinson, 2002: 2) but pedagogical practices can be 'a combination' of strong and weak forms' (Sadovnik, 1995: 11). Thus, rather than reducing pedagogical types into neat dichotomies, Bernstein's framework makes it possible to investigate the role of the 'values' of different elements of pedagogical discourse in promoting learning. The concepts of classification and framing make it possible for researchers to systematically describe pedagogical discourse across the various elements. It is this, which potentially allows the analyst to shift debates about the effectiveness of learner-centred or teacher-centred approaches from polemics to careful explanation of options and combinations.

Researchers such as Morais, Neves & Pires (2002), Morais & Neves (2001), and Neves & Afonso (2002), have provided a methodological model for doing just this. The model has been used for analysing pedagogical discourse across a fairly standardised set of elements. I summarise this model in the following section.

2. A MODEL FOR ANALYSING PEDAGOGY

Table 4 below summarises various elements of pedagogical discourse derived from Bernstein's framework and describes how they relate to the concepts of classification or framing.

Table 4: Elements of pedagogical discourse and whether they relate to power or control relations

PEDAGOGICAL DISCOURSE	
Instructional context	
Discursive relations (power relations: C+/C-)	
Inter-discursive relations	
• Relations between mathematics knowledge and 'everyday' knowledge	
• Relations between mathematics discourse and the discourse of other school subject	
Intra-discursive relations	
• Relations between mathematics discourses	
Discursive rules (control relations: F+/F-)	
• Selection rules	
• Sequencing rules	
• Pacing rules	
• Criterial rules	
Regulative context	
Hierarchical relations (power relations: C+/C-)	
• Relations between the teacher and learners	
• Relations between learners	
Relations between spaces (power relations: C-/C-)	
• Relations between the teacher's and learners' space	
• Relations between learners' spaces	
Hierarchical rules (control relations: F+/F-)	
• Teacher-learner communication relations	
• Learner-learner communication relations	

Bernsteinian researchers have mainly used the model to capture classification or framing over micro components of *classroom pedagogy* in relation to each element. They have mostly used it to describe and differentiate between the *how* of pedagogy in the teaching-learning context. For example, Morais & Neves (2001) and Morais, Neves & Pires (2002) used the model to show that specific elements of invisible and visible pedagogy should be 'mixed' in lessons. They suggest that the combination of weakened framing at the level of the hierarchical rules (regulative weakening) together with explicit evaluation criteria (instructional strengthening) improves learning outcomes for all learners, but specifically also for working class learners. Lubienski (2001) similarly shows that explicit evaluation criteria in lessons strongly correlate with improved performance. In primary science teaching, Morais, Neves & Pires (2002) further advocate weakened classification of spaces and inter-discursive relations, strong intra-disciplinary relations and weakened pacing within the classroom context.

Although researchers such as Morais, Neves & Pires (2002) have also demonstrated that ‘teacher competence’ is a necessary condition for teaching and learning, the model outlined has not been used to any great extent to describe the ‘*what*’ of learning. Studies have tended to focus on the micro code in the classroom, rather than on the specialization of learners’ identities through the macro code. In section 2, I will show how Bernstein’s concepts of classification and framing also provide an internal language for describing the ‘values’ of other elements of pedagogic discourse, more specifically related to the ‘vertical discourse’ dimension discussed in section 1.4 of this chapter. In section 2.1, I expand on this dimension by locating the OTL construct in Bernstein’s model of pedagogical discourse.

2.1 Locating OTL in the model

In Chapter 2, I outlined how OTL is defined as a four dimensional construct for the study. Table 5 below relates the four dimensions of the OTL construct to Bernstein’s language of description.

Table 5: OTL and Bernstein’s language of description

Dimensions of OTL	Bernstein’s language of description
Content coverage by cognitive demand; Content exposure; Curricular pacing.	Macro framing over pacing of curricular content across the academic school year/s
Curricular coherence.	Macro framing over sequencing of curricular content across the academic school year

Table 5 shows that the empirical construct OTL forms a dimension of the discursive rules and is located in instructional discourse. It relates to the discursive rules of framing over the pacing and sequencing of curricular content. It is useful for establishing comparable descriptions of framing over pacing and sequencing of curricular knowledge *across* academic school year/s - the ‘invisible’ dimension of Bernstein’s competence model alluded to in section 1.6. The OTL indicators ‘content coverage by cognitive demand; ‘content exposure’ and ‘curricular pacing’ relate to across grade/s framing over pacing of curricular content. In relation to Bernstein’s language of description, ‘curriculum coherence’ relates to across grade framing over sequencing of the curriculum. By inserting OTL into the Bernsteinian schema, we are able to see that opportunity to learn is moderated by the pace and order in which learners move through the curriculum at the *macro* level across successive grades.

In relation to Bernstein's principles of description, what the OTL construct allows us to consider is variation in framing over *macro pacing and sequencing* of curricular content at the level of *implementation* of the curriculum as opposed to *micro pacing and sequencing* within the face-to-face context of the classroom. Bernstein's distinction between competence and performance modalities has tended to focus researchers' attention on the regulative discourse or the discourse that drives dispositions and relations at the micro level of the classroom. His distinctions can in a sense be said to have encouraged researchers to privilege the regulative dimension of pedagogical discourse. Because attention has centred on the particular practices implemented in the classroom or the 'face-to-face' dimensions of pedagogy, the focus has largely been on framing over pacing and sequencing at the micro rather than the macro level.

What the OTL construct does is shift attention to macro level pacing and sequencing bringing the instructional dimension to the fore. Although discussions around discursive forms and knowledge structures and visible/invisible pedagogies refer to *external* framing and classification of curricular content at the level of the *intended* curriculum, the OTL construct appears to fill a gap in the discussion. It focuses attention on an apparently covert dimension of Bernstein's competence model – the specialisation of learners' identities through *macro pacing and sequencing* of curricular content.²⁷

Before I go on to discuss *external* classification and framing in South Africa's curriculum documents, I discuss Bernstein's theoretical predictions about the influences of curriculum and pedagogy on outcomes for low SES learners.

3. BERNSTEIN'S THEORETICAL PREDICTIONS ABOUT PEDAGOGIC PRACTICES AND SOCIAL CLASS

Much of Bernstein's work is concerned with 'how curriculum *and* pedagogy are related to the reproduction of inequality among social classes' and 'with specifying the processes within schools that could further the understanding of the persistent relationship between social class and academic achievement' (Hurn, 1993 in Sadovnik, 1995: 5). His work 'is distinguished by his long-standing effort' to link pedagogical processes (the *how*) and structures of curriculum (the *what*) in schooling to the inequalities of the British social class

²⁷ I use the terms 'macro' and 'micro' because I want to invoke the macro context as part of pedagogy and distinguish between micro and macro aspects of the pedagogic code.

structure (Berlak, 1982: 16). Sadovnik (1995: 10) notes that 'Bernstein's work on pedagogic discourse is concerned with the production, distribution, and reproduction of official knowledge and how this knowledge is related to structurally determined power relations.' His concern is with the consequences of the production and transmission of knowledge for different groups.

Bernstein (1990) describes 'a pedagogic practice' as 'a cultural relay: a uniquely human device (a pedagogic device; my addition) for both the reproduction and production of culture' (ibid: 64). He describes this pedagogical device in formal educational contexts as a three message system – pedagogy, curriculum and evaluation.²⁸

3.1 The pedagogic device

For Bernstein 'pedagogic practices are cultural relays of the distribution of power' (Bernstein, 1990: 73).

The pedagogic device makes possible the transformation of power (that is, its basis in social relations and their generating sites) into differently specialised consciousness (subjects) through the device's regulation and distribution of knowledges and of the discourse such knowledge presuppose (ibid: 189).

He argues that different pedagogical practices carry different 'consequences for those children who are able to exploit the possibilities of the pedagogic practices' (ibid: 74). Bernstein also asserts that, although conflicts evident between visible/performance and invisible/competence pedagogies are 'class conflicts', they are in fact conflicts only between two factions of the middle class (ibid). He argues that the working class does not participate in these conflicts.

To show how pedagogic practices can be intrinsically advantageous to children from middle-class or 'ruling class' backgrounds, Bernstein 'nuanced Durkheim's concept of the mechanical and organic and linked these to curriculum organization and educational identities' (Harley & Parker, 1999: 188). Essentially, mechanical solidarity refers to societies with a simple division of labour. Because the level of division of labour is simple, differentiation between individuals in such societies is low. Organic solidarity refers to a

²⁸ Bernstein (1986) distinguishes 'three different rules, which make up the pedagogic device: distributive rules, which make different forms of knowledge available to different groups; recontextualizing rules, which make up official knowledge; and evaluative rules, which make up pedagogic practices as they define what is transmitted' (Sadovnik, 1995: 28).

society with a more complex division of labour necessitating a more contractual kind of society and form or process of civil government. More industrialised societies have more complex divisions of labour and hence high differentiation between individuals (Harley & Parker, 1999).

Bernstein's distinction between visible/performance and invisible/competence pedagogies refers 'back to a distinction between two forms of organic solidarity within the middle class, individualized and personalised' (Ivinson, 2002: 2). Bernstein argues that, because of differences in patterns of child socialization, the middle class faction that is employed in the 'symbolic field' that is 'usually located in the public sector', is likely to argue for an invisible personalized pedagogy (Bernstein, 1990: 74) where dispositions such as creativity, reflexivity, self-regulation and autonomy are valued (Bernstein, 2000: 13). The middle class faction that is employed in relation to the 'economic field' and the 'production, distribution, and the circulation of capital', is likely to be opposed to invisible pedagogy and argue rather for a visible individualized pedagogy where dispositions such as 'persistence', 'carefulness', 'attentiveness' (Bernstein, 1975: 131), 'industriousness' and 'conscientiousness' (Bernstein, 2000: 13) are valued.

In section 3.2, I discuss how Bernstein's code theory (Bernstein, 1990) contributes to an understanding of the relationship between the socio-economic status of children's families and learner achievement in school and of the ways in which 'the institutions of society, particularly schools' reinforce mechanisms for excluding working class learners from forms of cultural capital such as high status knowledge and skills, and dispositions (Berlak, 1981: 16).

3.2 Bernstein's code theory

In section 1.6, I stated that, for Bernstein 'a code is a regulative principle, tacitly acquired, which selects and integrates relevant meanings' (Bernstein, 1990: 101). The primary concern of his code theory is 'how social class regulations regulate orientations to meaning' (ibid). According to Bernstein, all children come to school with codes for making sense of their local community contexts or personal experiences. However, he argues that learners from working class backgrounds are more likely to enter school with a 'restricted language code', whilst middle class children are more likely to enter school already also in possession of a

second more elaborated orientation to meaning which facilitates access to the specialized principles underpinning the structure of school knowledge (Bernstein, 1975).

3.2.1 Restricted and elaborated language codes

Restricted communication codes are found in 'narrower' societies where the socializing agencies within the system are 'well-defined and structured' (Littlejohn, 2002 in Young, 2002: 2). Elaborated codes are found in societies where individuality is valued and where the socializing agencies are 'more malleable' (ibid).

According to Atherton (2002)

The essence of the distinction is what the language is suited for. The restricted code works better than the elaborated code for situations in which there is a great deal of shared and taken-for-granted knowledge in the group of speakers. It is economical and rich, conveying a vast amount of meaning with a few words, each of which has a complex set of connotations and acts like an index, pointing the hearer to a lot more information which remains unsaid (in Young, 2002: 1)

Conversely

The elaborated code works well in situations where there is no prior or shared understanding and knowledge, where more thorough explanation is required. If one is saying something new to someone they've never met before, they would certainly communicate in elaborated code (Young, 2002: 3).

The elaborated code 'can "stand on its own", it is complete and full of detail, most overhearing a conversation would be able to understand it' (ibid).

Both working class and middle class children are provided with access to less formal restricted codes of communication for making sense of local contexts through their families and friends and other socializing agencies (Bernstein, 1975). However, working class children are less likely to have had even basic exposure to this second code because un-common sense knowledge is not usually available to most of them in their homes, for example, because their parents are illiterate or have low educational levels, or the children lack access to other cognitive resources such as books or computers at home. Bernstein suggests, that because working class children have less social, cultural and geographical mobility, they are less likely to encounter elaborated codes of communication with their more specialised vocabulary than middle class children who are more likely to have access to both

codes of communication primarily through their more individualised socialisation (Young, 2002).

Bernstein (2000: 107) illustrates this theory through research findings (Holland, 1981; Daniels, 1988, 1989, 1995) which suggest that middle class children are more likely to be effective in school because they come to school already familiar with the code or orientation to meaning that allows them access to un-common sense school knowledge. The research conducted by Holland (1981), for example, showed that seven-year old working class British children, when asked to classify items of food commonly found on their school lunch menu, initially drew on their common sense knowledge, personal experiences or localized contexts as the principle for classifying the food items (for example, 'Things I have for breakfast at home'). In contrast, middle class learners from the same age cohort were also able to draw on more specialized school-orientated principles or un-common sense knowledge (for example, 'These are all meat/vegetables/fish' etc.). Only after the task required them to draw on a different principle, did the middle class children choose to use more personalized or localized principles for categories of food items. Whilst the middle class children used two sets of classificatory principles, the working class children continued to draw only on personalised common sense classificatory principles.

The implication is that, because schools are attempting to transmit un-common sense knowledge, working class children are 'less likely to be oriented to producing what counts as legitimate meanings, and legitimate ways of realizing them, in contexts critical for educational success' (Edwards, 1991:271). In particular, they are less likely to make conceptual distinctions involving abstractions and generalizations. However, although working class children are less likely to have come across the school code prior to entering school, Bernstein (1990: 55) emphasizes that 'the difference between children' is 'not a difference in cognitive facility but a difference in the recognition and realization rules the children used to read the context and to create their texts: a code difference.' According to him, what gives middle class learners an advantage on entering school and makes learning school knowledge more difficult from the beginning for learners from working class backgrounds is that they differ in their possession of recognition and realisation rules (Cooper *et al.*, 1997). More specifically, middle class children are more likely to possess a specialized recognition rule.

3.2.2 Recognition and realization rules

Recognition rules are the means by which learners 'are able to recognize the speciality of the context that they are in', whilst 'realisation rules allow for the production of legitimate text' (Cooper *et al.*: 1997: 16) and determine 'how we put meanings together and how we make them public' (Bernstein, 1996: 32). It is the recognition rules that enable 'appropriate realizations to be put together' (*ibid.*). Cooper *et al.* (1997: 17) maintain that 'what Bernstein (1996) allows us to understand' is that a 'child's common sense response may result from patterns of socialization that have produced a set of recognition and realization rules which structure the child's responses to/in a variety of contexts'. 'The child's socio-culturally grounded perspective may have caused her (*sic*) to misrecognise the demands' of an 'academic context with the result that she has applied procedures and ways of thinking "appropriate" to one context to another where they are "inappropriate" or "illegitimate"' (Cooper *et al.*, 1997: 333317).

Essentially Bernstein's thesis is that working class children are less likely to enter school already in possession of an orientation to meaning which enables them to identify and realize specialized vertical discourse as opposed to everyday horizontal discourse and are, therefore more likely to select a non-specialised recognition rule inappropriate to an academic context (Bernstein, 2000: 19). However, as stated in section 3.2.1, unlike most other reproduction theorists, Bernstein's theory, in line with the school effectiveness literature described Chapter 1, stresses that the role of schooling in reproducing social inequality is not fixed. What is significant about his code theory is that it can be read as supporting the notion of strong *external* framing over macro pacing and sequencing of specialized vertical discourses in the 'official' or in the intended curriculum. As Rose (2002: 1) warns, when *external* framing is weak and sequencing and pacing rules of the intended curriculum are 'more or less hidden from teachers and their trainers, inadequate provision is made' particularly for working class learners 'who have not gained the prerequisite orientations'.

Bernstein's code theory is thus also useful for relating differences in the structure of the intended curriculum and the curriculum that is actually made available to learners (OTL) to the creation of educational inequality. In section 3.3, I will show how his analysis of the social class assumptions of pedagogical types provides guidance about what processes of knowledge transmission within the classroom may be more (or less) effective for learners from lower SES backgrounds.

3.3 The social class assumptions of invisible pedagogy

Bernstein's work suggests that, because implicit regulative aspects of invisible pedagogy are likely to be more aligned with the socialisation practices of middle class parents, they will at school be more familiar and accessible to middle class learners, and by the same token, less familiar and hence less accessible to working-class learners. Certain kinds of weak framing in invisible pedagogy are more likely to introduce a contradiction between the school and home experiences of working-class children. On the other hand, Lubienski (2001: 6) notes, the role of the teacher in visible pedagogy as 'rule-giver' and the role of learners 'in receiving explicit direction from the teacher appear 'more aligned with some aspects' of working-class cultures and child socialization.

The main concern for Bernstein is thus ways in which invisible pedagogy may actually make learning school knowledge more difficult for learners from working class backgrounds because of implicit instructional aspects of invisible pedagogy. For example, embedding the evaluation criteria in real world problem-solving (implicit evaluation criteria) can act as mechanisms for disguising the recognition rule and thereby excluding working class learners from high status knowledge, skills and disposition 'acquired and/or reinforced within the institutions of society, particularly schools' (Berlak, 1981: 16). In her work Walkerdine (1990 in Lubienski, 2001) observed that working class children became 'engrossed' in the everyday contexts used '(such as shopping)' rather than in 'gaining the intended mathematical knowledge' (Lubienski, 2001: 5). As Morais & Neves (2001: 216 in Lubienski, 2004) warn, invisible pedagogies disadvantage learners precisely because they 'leave the text legitimized by the school and society invisible' (Lubienski, 2004: 109). Rose (2002) also shows that implicit pedagogies in literacy education are disadvantageous to indigenous Australian children.

In addition, Bernstein points out that weak frame strength in invisible pedagogies 'pre-supposes a longer average educational life', and middle class children potentially have longer educational lives extended as they are by the home environment (Bernstein, 1990: 81). Furthermore, 'if middle-class parents are concerned that their child is not obtaining the basic competencies at the rate they expect' (because of weak framing over pacing or the reduced emphasis on the transmission and acquisition of specific skills in invisible pedagogy), 'they are more likely to be in the position' to organise an 'educational support system', either through private lessons or through their 'own efforts', or to make the choice of moving their

child to a private school or of actually moving near a different state school (Bernstein, 1975: 129; see also Ball, 2003). Moreover, as Berliner (1993 in Lubienski, 2001: 6) remarks, higher social-economic standing not only allows these 'parents to buy high quality' pre-schooling, but to purchase other cognitive resources for their children such as 'instructional toys, encyclopedias and computers' for home use, all of which provide learners with access to the elaborated codes and principles which underpin school knowledge.

Indeed, Bernstein (1990: 81) acknowledges that 'if all children left school at 14 there would be no invisible pedagogies'. He continues:

Its relaxed rhythm, its less specialised acquisitions, its system of control entail a different temporal projection relative to a visible pedagogy for comparable acquisition. Indeed, this fact is explicitly taken into account by many middle-class families who favour this regime in the early years of their child's life before switching to a visible pedagogy at the secondary stage. Such favouring families often run a compensatory pedagogic programme dedicated to reading, writing and counting whilst the child's creative potential may be facilitated by the invisible pedagogy of the infant or pre-school (ibid).

Also, because working class parents are less likely to share 'the underlying theory' of the forms and content of evaluation of invisible pedagogies, they are also more likely to be 'cut off from the evaluation' and 'less likely' to be able to understand and 'diagnose' their child's progress or to provide their own educational support system (Bernstein, 1990: 132). This is important because, if invisible pedagogy is 'to be successfully implemented in its own terms', 'a particular form of (middle class) (my addition) maternal primary socialization *and* (his italics) a small class of pupils *and* (his italics) a particular (school) (my addition) architecture', are assumed (Bernstein, 1975: 129). 'If the class is large' and the primary orientation of the child towards schooling is inappropriate and space is limited, as is more likely to be the case in schools serving poor communities, 'the teacher is likely to have great difficulty in providing the frequent individual assistance required by the pedagogy' (ibid).

In section 1.6, I suggested that, whilst regulative discourse is an explicit dimension of competence pedagogic models, an implicit dimension is the macro code. In the following extract, Bernstein suggests that middle class learners are more likely to experience those elements of the invisible pedagogy that enable them to access the correct code or dispositions

for future professional occupations through regulative weakening whilst still maintaining high chances of entry into further education. He identifies a need to establish whether it is possible to enable working class learners to experience this micro code whilst still ensuring that the 'invisible' macro code (high status knowledge and skills) is made available to them. He identifies a need to establish which elements of invisible pedagogy act as mechanisms for excluding working class learners in particular contexts from access to both codes.

The 'hidden curriculum' of invisible pedagogies may well be, embryonically, strong classification, albeit with relatively weak frames. It becomes a matter of some importance to find out which children or groups of children are particularly responsive to this 'hidden curriculum'. For some children may come to see or be led to see that there are two transmissions, one overt, the other covert, which stand in a figure-ground relation to each other. We need to know for which teachers, and for which children, what is the figure and what is the ground. Specifically, will middle-class children respond to the latent visible pedagogy, or are they more likely to be selected as receivers? ... (Bernstein, 1975: 132).

The implication is clearly that middle class learners will be able to read the 'latent' code, while working class learners will not.

3.4 The social class assumptions of visible pedagogy

Bernstein asserts that the social class assumptions of visible/performance pedagogy also 'disadvantage subordinate groups' (Sadovnik, 1995: 14). According to him, in visible pedagogy, 'if learners do not meet the requirements for each stage', 'three strategies 'may be applied' all of which will result 'in a stratification of acquirers' (Bernstein, 1990: 74). Either a 'repair system' such as extra lessons 'will have to be introduced'; or the child 'is given more time to meet the requirements' through relaxing the pacing rules, for example, through repeating a year; or the quality of the contents to be acquired will be reduced, for example, through, vocational 'streaming' (ibid); or other forms of tracking; or by weakened micro framing. Nevertheless, all these 'strategies produce a more delicate system of stratification within an already stratifying pedagogic practice' (ibid) because 'visible pedagogies entail a distribution of expected age-related discourses and those children who are unable to meet the sequencing rules particularly 'as they apply to reading become more dependent upon the teacher and upon oral forms of discourse' (ibid: 75).

This is because, unlike invisible/competence pedagogies:

In visible pedagogies there is usually a time interval between these different levels of discourse, in the sense that the local, context-dependent, context-tied operations come in the early stage of the pedagogic practice and the understanding and application of principles come at a later stage: the understanding of the principles even later. If children cannot meet the requirements of the sequencing rules and are caught up in the strategies of the repair system, then these children, often the children of the lower working class (including other disadvantaged ethnic groups), are constrained by the local, context-dependent, context-tied skills; by a world of facticity (Bernstein, 1990: 75)

In the USA, the relation between stratification through streaming and tracking and racial and socio-economic inequality is well-documented (see for example, Oakes, 1985; Oakes, Gamoran & Page, 1992).

Rose (2002: 2) points out that 'rather than addressing the needs of these students, the pacing of school curricula accelerates through upper primary and secondary schooling, ensuring that the gap between the most and least successful students widens'. By secondary school, good skills in reading, writing, and mathematics are assumed, and 'the pacing of the curriculum content, linked to evaluation timetables, ensures that there is no time to teach weaker students so-called basic skills' in numeracy and reading (ibid: 3). Because teaching and evaluation in senior school is 'explicitly focused on textual performance' and the content of texts (for example, mathematics) rather than on how to read them, skills in reading are assumed and no longer taught at these levels (ibid). As Bernstein (1990: 75) notes reading is an early requirement of the sequencing rules.

Bernstein (1990: 78) observes that the strong pacing of the academic curriculum in upper primary and senior schooling in visible pedagogy creates the necessity for 'two sites of acquisition' – school and home. 'Curricula cannot be acquired wholly by time spent at school' and 'time at school must be supplemented by official pedagogic time at home, and the home must provide a pedagogic context and control to the pupil to remain in that context' (ibid: 77). The child is expected to do homework and 'the family' is 'expected to ensure that the pupil has time' for homework and to 'have effective control over the peer-group practices of the child' (ibid).

For the children of the 'disadvantaged classes', most often 'there is no second site of acquisition' (Bernstein, 1990: 78). For one thing, 'official pedagogic' silent space and time are not usually available at home for these children (ibid). Furthermore, these children are 'doubly disadvantaged' because 'their orientation to language, narrative, is not privileged by the pedagogic communication of the school, either in form or in content' (ibid). 'The strong pacing rules of the academic curriculum' 'creates a particular form/modality of communication which does not privilege everyday narrative' and 'acts selectively on those who can acquire the school's dominant pedagogic code, and this is a social class principle of selection' (ibid).

Bernstein (1990: 71) points out that because visible pedagogy has explicit rules of discursive order, 'it does not mean that there are no tacit rules or messages, only that their meaning must be understood in the context of a visible pedagogy'. Bernstein (ibid) elucidates:

We can see that the pacing rule carries invisible social class assumptions which act selectively on those who can acquire the dominant pedagogic code of the school through the distributive consequences of the visible pedagogy's strong pacing and its regulation of the deep structure of sociolinguistic competence. Indeed where pacing is strong we may find a *lexical* pedagogic code where one-word answers or short sentences, relaying individual facts/skills/operations may be typical of the school class of marginal/lower working-class pupils, whereas a *syntactic* pedagogic code relaying relationships, processes, connections may be more typical of the school class of middle-class children, although even here pupil participation may be reduced (because of strong pacing – my addition) (page 79).

For this reason, Rose (2004) advocates explicit instruction together with relaxed framing over pacing and sequencing of the formal curriculum for socio-economically disadvantaged learners or learners from marginalized backgrounds; that is, strong macro framing and weak micro framing.

3.5 Discussion of Bernstein's predictions

Bernstein's analysis shows how the social class assumptions of both visible and invisible pedagogies are potentially disadvantageous to children from working class backgrounds or for children from other disadvantaged or 'subordinate groups' (Sadovnik, 1995: 15). What is important in relation to this study is that Bernstein (1990: 79) maintains that a visible/

performance pedagogy 'is not intrinsically a relay for the reproduction of differential school achievement among children from different social classes.' Certainly he believed that it is possible 'to create a visible pedagogy which would weaken the relation between social class and educational achievement' (ibid; see also Bourne's (2004) 'radical visible pedagogy'). For him the question is: 'How does power and control translate into principles of communication, and how do these principles of communication differentially regulate forms of consciousness with respect to their reproduction and the possibilities of change?' (Bernstein, 2000: 4). In other words, which features have the greatest potential to carry the possibility of interrupting the cycle.

Before I elaborate on the analytical framework for the study in section 5, I want to take into account the South African context. In section 4, I show how Bernstein's distinction between discursive forms and knowledge structures and his concepts of classification and framing are useful for analyzing the structure of Curriculum 2005 and the RNCS and the modality of socialization underpinning the curriculum, as well as for identifying an appropriate methodology for studying variations in mathematics OTL in the South African context in more explicitly theoretical terms.

4. THE SOUTH AFRICAN CONTEXT

In this section I discuss *external* classification and framing in South Africa's curricular documents.

4.1 The structure of Curriculum 2005 and the RNCS for numeracy and mathematics

In the 1991 version of C2005 (NDoE, 1997b, c & d) the distinction between everyday knowledge and codified school knowledge is weakly classified and integration between different subjects is promoted. What this weakly classified curricular discourse in the first version of C2005 does is collapse the boundaries between horizontal and vertical discourse and between codified knowledge structures reducing the power or 'cultural advantage' of the vertical discourse of school mathematics (Muller, 2000).

The distributive rules regulating the pacing and sequencing of specialized mathematics discourse are weakly framed in the curriculum documents. Consequently, the discourse of school mathematics loses many of its 'formal properties' making it both more difficult to assess its acquisition and indeed to ensure that all children receive an equivalent curriculum

(Muller, 2000). Teachers have control over the level of detail and degree of emphasis with which content is covered. However, as I suggested in section 1.6, an assumption underpinning weak *external* classification and framing at the level of the intended curriculum is that teachers at school level have strong enough internalized conceptual schema to ensure that the necessary specialized core knowledge and skills are made available to learners over each school phase in a way that the structured or conceptual relations within the subjects or disciplines are made apparent. As all the research available shows, this is a vain assumption in the South African context.

The RNCS for the numeracy and mathematics Learning Area (NDoE, 2002b) were not yet in use in the Intermediate Phase when data collection for this study was conducted. Nevertheless, in contrast to the 1997 version of C2005, they reflect what is currently considered to count as worthwhile mathematics knowledge for learners in South Africa. Classification between everyday and school knowledge has been strengthened. *External* or official framing over the rules regulating sequencing and pacing across each grade has been made visible. Thus, the new curriculum statements make it possible to analyse what schools and teachers are doing with the discretion currently available to them against the explicit requirements for each grade level. It is therefore possible to use the RNCS as a framework for assessing variations in the degree to which learners in different classrooms are being given access to school mathematics (see Chapter 4).

4.2 The desired modality of classroom practice in Curriculum 2005

As pointed out above, the degree of central, systemic control or *external* framing over the rules regulating sequencing and pacing of specialized knowledge in the curriculum documents currently in-use in South Africa in 2003 is weak. Conversely, at the policy level, the desired pedagogical practices for implementation of the curriculum are quite specific. The assumption is that it is a modality of classroom practice centred on the learner rather than the teacher and that stresses regulative rather than instructional discourse that optimizes outcomes that will reduce present inequalities.

In section 1.1.2 of Chapter 1, I discussed how South African curriculum documents promote a learner-centred pedagogy. In Bernstein's terms, this means that, at the micro level of the classroom, weak classification and framing is promoted so that

- boundaries between pedagogic spaces for teaching and learning are blurred to de-emphasise the teacher's position of power (weak classification of space in the classroom facilitates weakly framed social relationships between the teacher and learners);
- space and seating in the classroom is organized to promote learner interaction and collaboration (weak classification of space facilitates weakly framed social relationships between learners);
- the teacher's status or position of authority is 'masked' or 'downplayed' (Lubienski, 2004: 119) so that the fact that the teacher defines 'the characteristics of the instructional and regulative contexts' is hidden (Neves & Afonso; 2002: 3) and learners *appear* to be self-regulating and to take personal responsibility for initiating actions and following routines themselves (Teacher as facilitator; weak classification of hierarchical relations between the teacher and learners);
- learners 'have equal status in the pedagogic relation' (Neves & Afonso; 2002: 4) so that all learners have equal personal participation and intervention and possible academic and social hierarchies between them are blurred (weak classification of hierarchical relations between learners at the instructional and the regulative level);
- open communication relations between the teacher and learners are promoted so that learners can initiate interaction and share control with the teacher over the timing, content and duration of interactions (weak framing over teacher/learner communication relations);
- open communication relations between learners are promoted so that learners have opportunities to interact and collaborate with one another (weak framing over learner/learner communication relations);
- strong relations between real world or everyday knowledge and school knowledge are promoted and 'boundaries between everyday and school knowledge are diminished' (Lubienski, 2004: 119) (weak classification of school and everyday discourse);
- learners rather than the teacher *appear* to have more control over micro selection, sequencing, pacing and the criteria for evaluation:
 - learners *appear* to have a degree of choice over activities, materials or contents (weak framing over selection);
 - learners *appear* to have a degree of choice over the order of activities, materials or contents (weak framing over sequencing);

- learners *apparently* have a degree of freedom to work at their own pace or to influence pacing of activities, materials or contents (weak framing over pacing).
- learning takes place inductively through the exploration and discussion of real world contexts or problems rather than through direct expositions of procedures to be followed (implicit evaluation criteria/weak framing over the recognition rules);
- evaluation focuses on what is present or valuable in learners' products or 'texts for evaluation' rather than on what is missing (implicit evaluation criteria/weak framing over realization rules).

As stated earlier, in the more recent RNCS in South Africa, *external* framing over the rules regulating the discursive rules of macro sequencing and pacing of mathematics knowledge has been strengthened, particularly for the numeracy and mathematics Learning Area indicating a shift towards a more 'traditional' performance model. However, in section 1.6, I noted that, even where external framing at the macro level of policy or even the school level is strong and the discretion of the teacher over curricular content is reduced, teachers can still exercise more degrees of freedom over the instructional and regulative context available to learners within their lessons.

As indicated in section 3, even if this study finds that strong framing over macro pacing and sequencing (OTL) is more important in relation to enhancing achievement outcomes for low SES learners, there is still a need to investigate the potential of including 'elements of invisible pedagogy' in 'a performance regime' (Muller, 1998: 190). Indeed as Muller (*ibid*: 199) concedes there may be 'no option but to entertain the idea of mixed modes' as 'reflexive modernity' 'may well require a de-differentiation of specialised education provision in order to provide workers with high levels of knowledge and skills as well as generic competencies' or dispositions such as 'autonomy', 'creativity', 'independence' and 'initiative'. The question in such a context then becomes how can teachers include elements of *invisible* pedagogy without compromising the development of core specialised mathematical knowledge and skills? Is it possible to achieve 'a balance' which ensures the development of the pre-requisite specialised mathematics identities? (Muller, 1998; Morais & Neves, 2001).

Rather than the dichotomous from-visible/performance-to-invisible/competence curricular reform thinking currently reflected in South Africa's curricular documents and pedagogical policy, Muller suggests that we need to explore the potential of embedding 'elements of invisible pedagogy' in a performance 'regime', what he terms 'a visible pedagogic regime' (Muller, 1998: 190). For example, as mentioned in section 2, in their work in Portugal, Morais & Neves (2001) have found that a way for working class learners to 'learn the privileged text of schooling, including privileged discourse norms and curricular content while also becoming critical thinkers who can question authority' is for teachers to use 'their authority to make evaluation criteria explicit, while also weakening the hierarchical nature of the teacher-student relationship' (Lubienski, 2004: 120). The implication is that, rather than investigating 'type of pedagogy', the role of the different elements of the processes of knowledge transmission in promoting and enhancing or constraining and diminishing low SES learners' access to high status school knowledge, skills and dispositions needs to be explored.

However, as stated in Chapter 1, taking into account our current context in South Africa, budgetary constraints, and the extent of race and SES-based inequalities in academic achievement in South Africa (Case & Deaton, 1999; Anderson *et al.*, 2000; Crouch & Mabogoane, 2001), any attempt to achieve equity in achievement outcomes by weakening classification and framing appears to pose considerable risks for the country. Of particular concern for mathematics education are:

- the context in which teachers are expected to implement the curriculum, in particular, the weak specialization of time in schools and the amount of school time lost during the year so there isn't enough time for thorough teaching of topics and concepts (Taylor & Vinjevoold, 1999; Reeves, 2001);
- weak framing over selection, pacing, sequencing and the evaluative criteria tend to work against subject matter coverage, the conceptual advancement of specialized skills and concepts, and coherence in disciplinary knowledge;
- mathematics teachers whose own conceptual frames or schema are weak and who are thus much more likely to experience difficulties in weakening framing or classification within their lessons without lowering the level of content and cognitive complexity (Taylor & Vinjevoold, 1999).

In the final section of this Chapter, I present a conceptual framework derived from Bernstein's model of pedagogy. His model and concepts of classification and framing provide a framework for separating micro level practices evident within lessons from the curriculum made available to learners at the macro level across the academic school year/s.

5. A CONCEPTUAL FRAMEWORK FOR THE STUDY

Unlike the model presented in section 2, the framework that follows makes a methodological distinction between micro and macro level elements of pedagogical discourse. It separates out the OTL dimensions of pedagogical discourse from pedagogical practices in the classroom ('type of pedagogy'). The framework outlined is such that it should be possible to identify whether individual elements or combination of elements of pedagogy constrain or optimize low SES learners' access to specialized school mathematics.

5.1 'Opportunity-to-Learn'

The mathematics curriculum made available to learners is analysed using four key OTL variables related to Bernstein's concept of 'framing' over instructional discourse.

'Content coverage by cognitive demand', 'content exposure' and 'curricular pacing' can all be operationalised to variations in framing over *macro* pacing. The dimension 'content coverage by cognitive demand' measures variations in learners' levels of exposure to mathematics content at different cognitive levels. 'Content exposure' measures the estimated amount of time spent on mathematics contents. In Bernstein's terms 'content coverage by cognitive demand' and 'content exposure' both measure variations in pacing *across* the school year. 'Curricular pacing' measures whether there is conceptual advancement in mathematics content *across* grades so as to establish a proxy measure of a curriculum pacing trajectory for each classroom. In Bernstein's terms, 'curriculum pacing' measures variations in framing over pacing of curricular knowledge *across* adjacent grades. 'Curriculum coherence' measures the extent to which the sequence or order in which the various topics and sub-topics covered is underpinned by disciplinary principles. In relation to Bernstein's language of description 'curriculum coherence' measures variations in *across* grade framing over sequencing of the mathematics curriculum.

5.2 'Type of pedagogy'

Whilst OTL in the framework is defined as *across grade/s* framing over pacing and sequencing of curricular knowledge, 'type of pedagogy' at the classroom level in the study is defined as the extent to which elements of pedagogic discourse in classroom observations indicate a modality of classroom practice which is centred on the teacher or on the learner. The within-classroom face-to-face context is analysed using twelve variables in terms of the strength of the classificatory (power) and framing (control) relationship for the instructional and regulative contexts (Morais, Neves & Pires, 2002: 1).

At the level of the **instructional context**, pedagogical practices are analysed in terms of the

- strength of the classificatory relationship between everyday non-academic knowledge and academic mathematical knowledge. That is the extent to which mathematics knowledge and everyday knowledge are related to or insulated from one another;
- strength of the classificatory relationship between mathematical knowledge and other subjects or Learning Areas, or inter-disciplinary relations. This is the extent to which mathematics contents and other educational contents are integrated through the use of themes or distinct from one another.;
- strength of framing over the distributive rules, that is, the degree of control of the teacher or of learners over micro selection, sequencing and pacing and over the criteria for evaluation within lessons. For example, where framing over micro selection is weakened learners will *appear* to have a greater degree of choice or influence over activities, materials or contents. Where framing over sequencing within lessons is weak, learners rather than the teacher will *appear* to influence the order of activities, materials or contents. Where framing over pacing within lessons is weakened, learners will *appear* to work at their own pace. The evaluation criteria similarly may be weakly framed and implicit *a priori* in that access to criteria is through the exploration of everyday or real world contexts or they may be strongly framed and made explicit *a priori* through the teacher's direct exposition. Assessment may focus on what is present or valuable in learners' products or texts for evaluation (weakly framed realization rules), or assessment and feedback on error may focus on what is missing from learners' products or texts for evaluation (strongly framed realization rules).

Social relations between the teacher and learners are explicitly hierarchical where classification and framing over regulative discourse is strong. Where classification and framing over regulative discourse is weak, relations appear more symmetrical and learners are more likely to have opportunities to spontaneously respond in class and interact collaboratively with and help one another. In the study pedagogical practices at the level of the regulative context are analysed in terms of the

- strength of the classificatory relationship between agents – that is, relations between the teacher and learners, and between learners and their peers. For example, the teacher's status or position of authority may be unambiguous or it may be 'masked' so that the fact that the teacher defines 'the characteristics of the instruction and regulative contexts' is hidden (Neves & Afonso; 2002: 3). Learners' academic status or identities as mathematics learners may be based on individual performances which are used to differentiate between those learners who are able to respond successfully and those who are not. Alternatively, learners' academic statuses or identities may be de-emphasised so that possible hierarchies between appear to be 'blurred' (ibid: 4). Learners standing as mathematics students may be based on shared competence established through equal participation in joint productions and through personalised intervention from the teacher;
- strength of the classificatory relations between the spaces for teaching and for learning and in terms of insulation between individual learner's spaces. The idea here is that the classification of space in the classroom either facilitates or constrains weakly framed social relationships between the teacher and learners and between learners and their peers. Space and seating in the classroom can be organized either to promote learner interaction, for example, when learners are seated in groups in a shared or common space, or it may be organized so that it is easier for the teacher to control learner interaction or movement, for example, when learners are seated individually in rows. Pedagogic spaces for the teacher and the learners may be clearly demarcated to emphasise the social distance between the teacher and learners or the boundaries between their respective spaces can be blurred to de-emphasise the teacher's position of power;
- strength of framing over the hierarchical rules, that is, the degree of control by the teacher or learners over the communication relations. Weak values of framing over teacher-learner communication relations indicate open forms of communication where

learners appear to share control with the teacher over who initiates or participates in communication relations and over the timing, content and duration of teacher-learner interactions.

5.3 Analytical framework

Table 6 below summarises the conceptual framework for the study in terms of Bernstein's language of description. The framework renders the OTL dimension of pedagogical discourse sufficiently conceptually independent from 'type of pedagogy' for the two dimensions of pedagogical discourse to be operationalised for the empirical study. Table 6 illustrates that the OTL dimensions pertain to framing over the discursive rules and foreground the instructional aspect of framing over pacing and sequencing.

Table 6: Conceptual framework for the study

PEDAGOGICAL DISCOURSE				
OPPORTUNITY TO LEARN (MACRO LEVEL)			TYPE OF PEDAGOGY (MICRO LEVEL)	
OTL	Bernstein's language of description	Variables	Bernstein's language of description	Variables
INSTRUCTIONAL CONTEXT				
			INTER-DISCURSIVE RELATIONS (CLASSIFICATION)	
			<i>Relations between the specialised discourse of school mathematics and non-academic 'everyday' discourse</i>	Degree to which the boundary between mathematics discourse and 'everyday' discourse is distinct or 'blurred'.
			<i>Relations between the specialised discourse of school mathematics and the specialised discourses of other Learning Areas</i>	Degree to which the boundaries between mathematics knowledge and knowledge of other school subjects are distinct or 'blurred'.
DISCURSIVE RULES (FRAMING)				
			<i>Within lesson framing over selection/micro selection</i>	Degree to which the teacher or the learners appear to have control over micro selection
Content coverage by cognitive demand	<i>Across grade framing over pacing/macro pacing of curricular content</i>	The maths contents covered; the emphasis given to the contents; and the cognitive level at which the content is covered.	<i>Within lesson framing over pacing/micro pacing</i>	Degree to which the teacher or the learners appear to have control over micro pacing
Content exposure	<i>Across grade framing over pacing/macro pacing of curricular content</i>	'Academically engaged time', and the estimated amount of time spent overall on the maths contents.		
Curriculum pacing	<i>Across grades framing over pacing/macro pacing of curricular content</i>	Pacing of the curriculum across adjacent grades.		
Curriculum coherence	<i>Across grade framing over sequencing/macro sequencing of curricular content</i>	The internal coherence of the order or sequence in which the maths curriculum is covered.	<i>Within lesson framing over sequencing/micro sequencing</i>	Degree to which the teacher or the learners appear to have control over micro sequencing
			<i>Within lesson framing over the criteria for evaluation</i>	Degree to which the criteria for evaluation are implicit or explicit a priori
			<i>Within lesson framing over criteria for legitimate realizations of texts for evaluation</i>	Degree to which evaluation focuses on what is present or valuable in learners' texts for evaluation or on what is missing

REGULATIVE CONTEXT				
			RELATIONS BETWEEN SPACES (CLASSIFICATION)	
			<i>Relations between space for teaching and space for learning (C¹).</i>	Degree to which the boundary between the pedagogical spaces for teaching and for learning are 'blurred' or distinct.
			<i>Relations between learners' spaces.</i>	Degree to which the boundaries between learners' spaces are 'blurred' or distinct.
			RELATIONS BETWEEN AGENTS/SUBJECTS (CLASSIFICATION)	
			<i>Relations between the teacher and learners.</i>	Degree to which the hierarchical relations between the teacher and learners is 'masked' or clear.
			<i>Relations between learners.</i>	Degree to which the hierarchical relations between learners are 'masked' or clear.
			HIERARCHICAL RULES (FRAMING)	
			<i>Within lesson framing over communication relations between the teacher and learners.</i>	Degree to the teacher or learners <i>appear</i> to have control over teacher-learner communication relations
			<i>Within lesson framing over communication relations between learners.</i>	Degree to which communication relations between learners and their peers are opened or closed.

As pointed out in section 2, most Bernsteinian studies tend to bring the regulative aspect of pedagogical discourse to the fore by privileging the micro code in the classroom because they thereby omit a substantive part of the discursive rules (the 'what') that belongs to the macro context. Researchers have mostly used the model to capture classification or framing over micro components of different lessons in relation to each element. They have characterized differences in the teaching and learning context by describing framing or control over pacing and sequencing at the face-to-face or *micro*-level of lessons.

The conceptual framework for this study includes macro level dimensions of framing over pacing and sequencing making more of the 'vertical'/instructional discourse dimension of pedagogical discourse distinguishable. The OTL construct foregrounds the instructional aspect of framing over pacing and sequencing of curricular content thereby privileging the learning of disciplinary knowledge. Earlier I referred to the fact that in formal schooling 'the specific specialized skills and attributes of a visible pedagogy are beneath the surface of an

Chapter 4

RESEARCH DESIGN AND METHODOLOGY

1. RESTATING THE PURPOSE AND AIM OF THE STUDY

In Chapter 1, I explained how in South Africa, particular pedagogical approaches such as co-operative learning and real world problem solving are believed to improve learning outcomes. I further explained that the dominant explanation in large-scale educational research studies internationally is that OTL has a powerful effect on learning outcomes (Husen, 1974 in Schmidt & McKnight, 1995; Schmidt *et al.*, 1997a; Shavelson *et al.*, 1989; Burstein, 1993; Porter & Smithson: 2001). We have little information on the effects of OTL in the South African context. Large-scale studies have used teacher experience and qualifications as a proxy to show that teachers' subject expertise is related to achievement (see for example, Crouch & Mabogoane, 2001), but, as discussed in Chapter 2, teachers' subject knowledge is not a measure of the curriculum actually made available in the classroom.

This study aims to establish whether the OTL research findings from international studies and large-scale studies in developed countries are sustained in the South African context. In accordance with the international evidence, the expectation is that OTL will have a greater effect on achievement outcomes than 'type of pedagogy'.

Chapter 2 provided a working hypothesis that the four dimensions of the OTL construct will have greater effects on the achievement of low SES learners than the measures of 'type of pedagogy' outlined in Chapter 3.

Chapter 4 provides the research methods for study, variables for measuring OTL and 'type of pedagogy', data sources, times of data collection, the instruments used in data gathering, and data analysis processes.

2. RESEARCH METHODOLOGY

2.1 Research questions

The specific research questions for the study are:

- Does OTL in schools serving low SES communities in the Cape Peninsula influence achievement more than ‘type of pedagogy’?
- Are there interactions between certain OTL and pedagogy variables in relation to increases or decreases in learner achievement? For example, are certain combinations of framing over macro pacing and framing over micro pacing related to learner achievement?
- Are certain combinations of elements of pedagogy associated with the achievement of low SES learners? For example, is a combination of weakened framing over teacher-learner hierarchical relations together with explicit evaluation criteria related to improved achievement as is asserted by Morais and Neves (2001) and others?
- Do certain dimensions of OTL have more influence on achievement than others?
- Which home background factors interact with which elements of OTL/pedagogy in relation to achievement?

2.2 Research design

The dependent, ‘response’, or ‘product’ variables (Rowan, 2002: 9) for the study are measures of individual learners’ mathematics outcomes. The independent, ‘predictor’, or ‘process’ variables (ibid) are various measures of:

- ‘Opportunity-to-learn’; and
- ‘Type of pedagogy’.

An experimental or quasi experimental research design was not possible in this study. As the researcher I was in no position to offer a ‘matching’ treatment as advocated by Rowan, Correnti & Miller (2002). In 2003 there was no intervention offered in the Cape Peninsula that focused on the OTL ‘variables of interest’. Moreover, because schools that participate in interventions either self-select or are selected on the basis of other criteria such as location, need or willingness to participate, they are rarely, if ever, randomly assigned (Taylor & Vinjevold, 1999a). Selecting schools on the basis of poor and better achievement was also not viable since test results that would have made this possible were not available. Systemic

testing at the grade 6 level had not taken place in the Western Cape prior to 2003. In any case, using test results, such as available grade 3 systemic results, as a basis for selection would have compromised the representativeness of the sample (Taylor *et al.*, 2003).

A relational research design is one where the aim is to establish the relationship between naturally occurring predictor variables and the response variable of a random sample of low SES learners from the Cape Peninsula. A limitation of the relational design is that, because it looks at 'naturally occurring' variations, optimal levels of the variables of interest are very unlikely to occur. Classrooms are likely to be operating below 'the real (and obtainable) production frontier' (Rowan, 2002: 20). As Rowan, (*ibid*: 24) observes, because 'potentially idiosyncratic variations' are studied, 'naturally occurring' non-experimental data is probably 'less efficient than experimental data in making causal inferences'.²⁹ The 'typical – non-experimental – survey study' of classroom effects on achievement 'probably builds knowledge more slowly and more tenuously, than experimental research.' (*ibid*).

In planning the study I faced a number of other methodological dilemmas and decisions.

2.2.1 Methodological issues

- a) The intention of the study was to use statistical methods to analyse data so as to warrant generalizations. The sample size of classes and schools for the study was constrained by time, travel and funding, and I wanted to ensure as large a sample as was feasible and affordable. I decided to use the individual learner as the unit of analysis and to compare all learners with each other rather than to compare classes or schools because the sample size of learners was more likely to be large enough for the purpose of the study. Using learners as the unit of analysis was also consistent with the overall goal of providing information on differential mathematics achievement amongst low SES learners.
- b) The study entailed identifying appropriate measures of achievement outcomes and creating mechanisms for establishing comparable qualitative and quantitative differences or similarities in levels of learners' exposure to OTL and 'type of pedagogy'. The

²⁹ Rowan (2002 24) reports on a study by Lipsey and Wilson (1993) on 74 meta-analyses of experimental and non-experimental studies that showed that 'the *average* effect sizes for various causal hypotheses did not differ much between experiments and non-experimental studies, but that *variation in effect size* was much larger for the non-experimental studies' (his italics).

methodological mechanisms employed needed to make it possible to reflect the relationship between differential levels of learner achievement and differential levels of exposure to the two focal areas through statistical procedures (see section 3.2 and 3.3 of this chapter for details). Clearly, it was simply not possible to take into account the differentiated exposure to OTL and 'type of pedagogy' of individual learners within the same classes in a study of this scale (Lee, 1982). Because learners within each class were taught by the same teacher/s, they were considered to receive equivalent exposure (Wang, 1998: 145). This meant that individual learners in the same classes received the same value for all of the 'type of pedagogy' and all (except one) of the OTL measures. In other words, values for the various measures of OTL and 'type of pedagogy' did not vary across individuals in the same class because values ascribed to classes were transferred to learners. The only individual level OTL variable used in the study was the number of days each learner was marked absent in the class register. However, the statistical analysis attempts to account for the 'nested' nature of the OTL and 'type of pedagogy' data (see section 5 for details).

- c) As discussed in Chapter 1, strong correlations between family income and learner achievement are widely recognised internationally and in South Africa (Coleman *et al.*, 1966, Rowan, 1995; Crouch & Mabogoane, 1998). To control for this, I tried to ensure homogeneity of SES amongst the sample rather than include higher and lower SES learners in the study. The idea was to control the variation of SES and thus to attribute any differences in learner achievement to the variables of interest. A further reason for ensuring relative homogeneity in SES was that the effectiveness of particular pedagogical practices could vary for learners from different socio-economic backgrounds. In Chapter 2 and 3, I discussed the ways in which Bernstein's work suggests that different classroom practices may have different effects for learners from different social-economic backgrounds. My sampling objective was thus to ensure that learners' variability in terms of SES was as slight as possible (see section 2.4 for details on the sampling procedure). The intention was not to compare the experiences of lower- and higher- SES learners but rather to select learners who were most comparable and from as homogeneous a socio-economic background as possible. A potential risk was that I might not find as much variability in the variables of interest as I would in a study that cut across SES.

- d) Fourthly, I determined that a key control variable for the dependent variable in the study was learners' prior achievement. Porter & Smithson (2001: 63) argue that linking the enacted curriculum to outcomes necessitates 'a more narrow measure of achievement' than learners' scores, through the use of 'achievement gain measures' so as to control for prior achievement and learners' SES.

Rowan, Correnti & Miller (2002: 3) further call attention to the fact that '*achievement status* (their italics) – that is, achievement scores at a single point in time' 'results not only from the experiences students had in particular classrooms during the year of testing, but also from *all* (their italics) previous experiences students had, both in and out of school, prior to the point at which their achievement was assessed.' Relating achievement attained, for example, through a 'once-off' test score, to measures of learners' exposure to OTL and to particular pedagogical practices during the tested year, would not control for exposure in previous grades as would measures of learning gain (for example, through the use of pre- and post-test scores).³⁰ Using 'once-off' measures of achievement attained would make it difficult to establish relationships between variations in the two areas of interest and variations in measures of the mathematics outcomes for the sample. Controlling for prior achievement also seemed important because learners who started at lower levels of achievement could actually show larger gains over the year which would not be reflected in achievement scores.

'Once-off' test scores are also 'highly associated with family background' (Floden, 2003: 256). For example, SIMS investigators found that including prior achievement in their analysis, looking at learning across the year rather than achievement, greatly reduced the influence of home background variables. The argument is that:

The background characteristics of students are not strongly related to growth because the pre-test removes an unknown but large portion of the relationship between those characteristics and the post-test (Kifer and Burstein, 1992: 340 in Floden: 2003: 257).

³⁰ Sheerens & Bosker (1997: 182-209 in Rowan 2002) found that when studies measure learner achievement 'at a single point in time (and without controlling for differences among students in social background and prior achievement), about 15-20% of the variance in student achievement lies amongst schools, another 15-20% lies among classrooms within schools, and the remaining 60-70% of variance lies among students' (Rowan, 2002: 2).

However, a major limitation of a model that looks at learning gain across a year rather than achievement attained is that it also potentially removes a large part of the effects of curricular pacing (content coverage in earlier years) by controlling for the effects of differences in curriculum based on those prior experiences (Schmidt & Burstein, 1992). Comparing learning gains across the year could reduce the influence of one of the key OTL variables - the effects of curricular pacing in prior years. Indeed, Rowan, Correnti & Miller (2002) argue that both achievement scores and gain scores are unreliable measures of underlying overall achievement scores because they disguise 'true' differences in learner achievement. Their review of the literature on achievement studies supports the view that effect sizes derived from such models may under-estimate the effects of experiences prior to the school year. Such measures may under-estimate the 'cumulative' effect that within- and across-grade content coverage (curricular coverage and pacing) have on 'overall' growth in achievement. In a given year the effects may seem small but if learners are consistently exposed to higher levels of content coverage, the accumulative effects on learner achievement over the course of primary schooling may actually be quite sizeable – producing greater academic variation/differentiation in learner achievement than indicated.

Rowan, Correnti & Miller (2002) suggest that a possible solution is to use 'statistical models that directly estimate students' individual "growth curves"' (Rogosa, 1995 in Rowan, Correnti & Miller, 2002:5). Apparently statistical packages are now available for estimating learners' 'growth curves' if there 'are at least three data points on achievement for most students in the data set' (Rowan, Correnti & Miller, 2002: 5).³¹ These authors make a case for 'interrupted time series' 'analyses in which data on outcomes are collected at multiple time points' (ibid). They further argue that, to produce 'differences of magnitude', this should be done 'before and after exposure to some treatment focusing on the variables of interest (ibid). Clearly, such an approach was beyond the scope of this study. A compromise was necessary.

I made a decision to use a model that controlled for the effects of learners' prior school experiences by measuring achievement gain across one year through the use of two (pre-

³¹ Apparently a limitation is that these packages cannot yet 'be used to estimate the percentages of variances in rates of achievement growth lying among classrooms within schools over time' (Rowan, Correnti & Miller, 2002: 5).

and post-test) measures. The availability of learners' pre- and post-test scores would allow me to at least explore the relationships between achievement attained and the effects of curricular pacing in prior years. As 'the school year is the unit for curricular planning' (Hirsch, 1999: 28), achievement gain in the study was determined through the use of a pre- test measure of prior achievement at the beginning of the academic school year in 2003 and post-test measures of achievement gains as close as possible to the end of the school year in 2003 (see section 3.1 for details).

- e) Fifthly, although an effort was made to ensure that the sample's variability in terms of SES was as slight as possible, a major constraint in assessing the effects of the predictor variables on learning gain is that individual learners are also likely to differ in many other ways that also predict achievement (Rowan, 2002: 23). For this reason I decided to take into account and control for the effects of individual level background variables that, according to international literature and available evidence from South African research, 'can exercise direct effects on' achievement 'and/or condition the effects' (ibid) of predictor variables on the response variable. Individual background data was collected and included in the statistical modeling (as distinct from the 'standardised' or 'community' proxy used for socio-economic status in the sample selection). Unlike the OTL and 'type of pedagogy' measures, these learner background variables such as gender, age and whether or not learners have basic cognitive resources at home, are measured on an individual basis and thus vary across individuals in the same class (see section 3.4 of this chapter for details).

2.3 Sample selection

The sampling goal for the study was to select a large enough sample of low SES learners sufficiently representative of the population of low SES learners from high poverty districts in the Cape Peninsula so as to be able to validly use statistical methods to analyse data and warrant generalizations. Expanding the sample beyond these districts was simply too costly and impractical this study.

An original sample of grade 6 mathematics learners from predominantly low income communities in the Cape Peninsula was drawn using the following two-stage cluster sampling approach designed to yield a sample of at least 900 low SES learners:

1) The Western Cape Education Department (WCED) granted permission for the research to be conducted in the four Cape Peninsula Education, Management and Development Centres (EMDC) or districts with the highest number of schools serving low SES communities. WCED approval to conduct the research was granted to me subject to the following key conditions:

- schools, staff and learners were under no obligation to participate in the research;
- schools and participants should not in any way be identifiable in the reporting;
- the research should not be conducted during the fourth school term;
- the Departmental letter of approval and conditions was submitted to school principals at the intended sites.

The WCED provided data from their poverty index database on primary and intermediate phase schools which had grade 5 and 6 classes in the four districts. The data included information on school fees.

I used 'low school fees', defined as less than R200, as a proxy for schools serving low SES communities.³² The rationale for this was that the South African Schools Act allows school governing bodies to set school fees with the proviso that state 'schools cannot set fees that are more than one-thirtieth of the combined annual gross income of the parents of more than a tiny proportion of the school's pupils' (Seekings, 2001a: 183).

Using 'low school fees' as a proxy for low average community wealth was the most reliable and readily available proxy for income level given that accurate data on parental income or household wealth and the education levels of parents or main caregivers (traditionally the main indicators of SES) have proven to be extremely difficult to obtain, particularly if this has to be done via learners from poor backgrounds where parents or caregivers have low levels of formal education and literacy [see for example, the Human Science Research Council's Quality Learning Project (QLP) which found that learner's responses to questions about levels of parental education were inflated when compared with mean levels as reflected in the Census data (Taylor *et al.*, 2003: 29)]. Furthermore, a South African study by Van der Berg and Burger (2002) found a strong enough

³² I did not use the Community and Parents Index (CPI) from the Western Cape Schools Audit Result's (2001) as this index includes indicators of school/community/parent relations such as whether parents have an association to help the school; whether parents receive regular progress reports; whether school encourages learners to respect their environment rather than indicators of income level. Some low-income schools may be more successful than others in achieving parental involvement and participation. However, a hidden selection bias cannot be ruled out – parents may exercise a choice on the basis of perceived desirability and try to get their children into certain classes in certain schools. Although this is less likely with this category of schools, such self-selection could bias coefficients upwards.

association between school fees and matric results to warrant the use of annual school fees below R100 in 1997 as a proxy for low SES.³³

I then used the WCED poverty index data to identify the three hundred and twelve schools from the four metropolises/districts - Central, East, North and South that had, at the same point, grade 6 classes and annual school fees of less than R200.³⁴ A computerised random number generator was used to select a sample of 42 schools from this possible pool of 312 schools. This sample of 42 schools was selected proportionally according to the number of primary and intermediate schools with fees of less than R200 in each of the four districts. The idea was to match the ratios that existed in the population. The sample of 42 schools comprised 6 schools from Metropole Central (MC), 9 schools from Metropole East (ME), 12 schools from Metropole North (MN), and 15 from Metropole South (MS).

Originally my intention was to draw the random sample of at least 900 grade 6 maths learners from 30 classrooms in about 20 schools (pre-/post testing 30 learners per class with the individual learner as the unit of analysis). I anticipated that there might be more than one grade 6 maths teacher at some schools so that more than one class could be tracked at the same school. However, because schools also sometimes either have only one grade 6 class or only one maths subject teacher who teaches all the classes at the grade 6 level rather than a number of grade 6 class teachers teaching maths, and, because teachers could be replaced for various reasons, such as teacher accouchement leave, resignations etc., and replacement teachers might be unwilling to participate in the research, I decided to inflate the planned number of schools to 25 rather than run the risk of having fewer than 30 classes with different teachers. Previous experience of school-based research had shown me that the number of teachers who would take grade 6 mathematics classes at most schools would only be firmly established in 2003. The decision was to pick at random at least 30 mathematics learners from each of the classrooms, in case of learner attrition or 'drop out', unless there were fewer than 30 in the class in which case all learners in a class would be tested.

³³ Van der Berg & Burger (2002) used the School Register of Needs to establish that, in 1996, the average fee per learner was R113.

³⁴ R200 was used because a histogram of available data on fees of 479 primary or intermediate schools with grade 6 classes in the four districts showed that the fee for the majority of schools with low fees was less than R200.

- 2) In the third term of 2002, I first contacted school number 1 for each EMDC and subsequently contacted the rest of the schools in each list for each EMDC in random numerical order until 25 schools spread proportionally across the four districts had agreed to participate in the study.³⁵ If a school or teachers at a school declined to participate then these schools were 'replaced' with the school with the next randomly computer generated number for that EMDC. Only one of the schools I initially approached decided not to participate and was replaced. By the end of the fourth term of 2002, I had successfully negotiated firstly with the school principals and later with grade 6 and 5 maths teachers for 2003 (where these were known) from twenty five schools spread across the four districts. By the end of the negotiations in 2002, of the 25 schools who had expressed a willingness to make a commitment to participate in the study, 3 were from MC, 6 were from ME, 7 were from MN, and 9 were from MS. It was too soon for most of the schools surveyed to confirm how many grade 6 mathematics classes they would have in 2003 and who the teachers would be. In most situations, the number and names of teachers who would take grade 6 mathematics classes could only be confirmed in the first term of 2003.

At the beginning of 2003, ten of the selected schools reported that they had more than one grade 6 mathematics class with teachers who were willing to participate in the study. It seemed that a total of forty grade 6 mathematics classes would be participating. Three classes were from schools in MC, eight classes were from schools in ME, eleven classes were from schools in MN, and eighteen classes were from MS. At the last minute, a further school from MC dropped out. In the end 24 schools and 38 classes participated in the study. Prior to 1994, under apartheid, 19 of these schools were House of Representatives (HoR) schools (for 'coloured' learners) and 5 of the schools were Department of Education (DET) schools (for black learners).

The above sampling approach yielded an initial sample of 1 164 grade 6 mathematics learners from low SES backgrounds who wrote the pre-tests. The achieved sample for the study size is based on learners who participated in both the pre- and post- test. 163 learners from the initial sample were absent for the post- test and 1 001 learners from the original sample wrote both the pre- and post- tests. Learners were 'lost' for various

³⁵ School principals were first contacted telephonically. Details of the research were then faxed to the schools. I subsequently visited all sites at least once but in most cases twice in 2002 to explain the study to the principal, relevant department heads and potential teachers. At the beginning of 2003 follow-up meetings were held with grade 5 and 6 mathematics teachers to gain and ensure their support for and commitment to the research.

reasons besides learner attrition. Towards the middle of the year in 2003, a whole class of 30 learners from a school in ME was dropped from the study because of difficulties arising from teacher ill-health. (A second mathematics class from this school remained in the sample.) Test administrators reported low learner attendance in the only class tested at one school at the end of the third term largely because internal problems at the school had resulted in protest and turmoil in the community and in children staying at home for safety.

All the schools and teachers were requested not to tell learners that they were being tested before the pre- and post-tests were administered to pre-empt absenteeism on the day. An examination of pre-test results of all learners who were absent or missing for the post-test as well as the pre- and post-test results of those learners who wrote both tests did not suggest any patterns in absence rates. On average 3-4 learners per class were absent on the day of the post-test, although in some classes all 30 learners were present. Absenteeism across the classes appeared arbitrary and the loss of 163 learners from the original sample is not considered to have altered the representativeness of the sample.

Ultimately, the research analyses data from a random sample of 1001 low SES learners in 38 classes in 24 schools from four Cape Peninsula EMDCs or districts - Metropole Central, East, North and South. Table 7 in Appendix 1 provides details.

The mean school fee for the sample of 24 schools was R100. Fees ranged from R200 - R30. Table 8 in Appendix 1 shows frequencies for school fees.

3. OPERATIONALISING THE VARIABLES

The aim of the study is to investigate the relative effects of measures of OTL and classroom pedagogy on measures of the mathematics achievement gains of a random sample of low SES grade 6 learners from four districts in the Cape Peninsula over one school year. The analytical objective is thus to establish

- whether there are relationships between measures of the mathematics achievement of a sample of low SES learners and operational concepts of 'opportunity-to-learn' and 'type of pedagogy'; and
- which of the two relationships is stronger.

The dependent and independent variables had to be operationalised so that they could be defined and measured for assessing the relationship between measures of mathematics achievement gains of learners (see section 3.1) and measures of learners' exposure to measures of the two constructs, a) 'opportunity-to-learn' (see section 3.2) and b) 'type of pedagogy' (see section 3.3) over one school year. In order to ensure that data collected within and across classes were comparable, standardised data collection instruments were developed and used as far as possible.

3.1 Achievement gains

Grade 6 mathematics achievement gains for the study are determined through the use of standardised test scores. Ostensibly measures of 'creativity', 'problem-solving' and 'higher order skills' through the use of assessments comprising 'hands-on', practical and creative tasks appear more congruent with learner-centred approaches in that they reflect 'active, inquiry-orientated, hands-on teaching and learning' (Harman *et al.*, 1997: 5). However, available empirical work in South Africa has revealed that obtaining statistically significant evidence of learner ability poses a particular challenge in typical South African school contexts (Reeves & Long, 1998a & b; Joint Education Trust, 2000, Ensor *et al.*, 2002). Indeed, available evidence indicates that, certainly in the current context, performance tasks or 'authentic' assessments are less likely to allow for comparative assessments of learner achievement than standardised tests because the complexity of the presentation of performance tasks and the tasks themselves tend to work against establishing measures of learner performance. For example, one of the PEI studies (Reeves & Long, 1998b), used contextualised performance tasks as one measure of the attained curriculum. The researchers found that most learners struggled to perform the tasks autonomously. They struggled to read and understand complex information and extended text, to use the scientific representations and data they were given independently, and to communicate effectively through writing (ibid).

One of the greatest difficulties inherent in performance forms of assessment, even in developed country contexts, is that of eliciting a wide enough range of learner performance, 'both from a subject matter perspective and from the perspective of the student behaviors necessary to complete the task' (Harman *et al.*, 1997: 7). Winfield & Woodard (1994: 17) argue that 'familiarity with the context' of most performance-based tasks biases outcomes in favour of 'certain racial/ethnic groups' and that early studies in the USA have shown that

‘the achievement gap between subgroups’ is likely to remain the same or even increase on performance-based measures. In the USA, Darling-Hammond (1994a & b) and others have similarly cast doubts on the fairness of using performance assessments in high stake national testing, arguing that they may not reflect the underlying mathematics competence of certain groups of learners.

Certainly, in larger-scale assessments, any ‘benefits of performance assessment’ particularly for developing countries, ‘in terms of the extra information it may provide about student achievement, must be balanced against the extra cost and complexity inherent in this mode of assessment’ (Harman *et al.*, 1997: 6). Besides the enormous challenge of creating effective measures for testing problem-solving skills or creative abilities, such forms of assessment make considerable demands in terms of time, materials required, and ensuring that administration and assessment procedures are standardised (ibid). Obtaining measures of learners’ general ability in, mathematics or science for example, through the use of pen-and-pencil tests is both less costly and, research suggests, appears more likely to show variances making it possible to measure correlations between processes in the classroom and differences in the achievement gains of low SES learners.

Furthermore, research findings ‘that facts and skills are both necessary’, particularly at earlier school levels, ‘for the meaningful development of higher-level cognitive skills’ and ‘effective problem-solving’ to take place at higher school levels (Rosenshine & Meyers in Chall, 2000: 85), support the view that standardised test scores can provide useful proxy measures of outcomes that facilitate and provide opportunities for further learning. Hirsch (1999: 3) asserts that ‘whatever the shortcomings’ of standardised tests, ‘no one has plausibly denied that they show a consistent positive correlation with real academic competencies. He argues that in the USA ‘if reform efforts of the past decade *were* significantly improving our children’s academic competencies, then the standardised tests, however imperfect, would yield some indication of it’ (ibid – his italics).

3.1.1 Tests used in the study

The tests that are used for determining differences in achievement gains for the present study are a selection of items from the ‘Grade 6’ mathematics tests developed by the Joint Education Trust in consultation with the national Department of Education, provincial departments and teacher unions and the Instituut voor Toetsontwikkeling (CITO) in Holland

(Joint Education Trust, 2001: 5). Grade 6 is in inverted commas for the following reason: The results for mathematics test items developed earlier for Grade 3 learners had already shown 'that learners were performing well below the grade requirements. This suggested that a Grade 6 level test in the same schools would not provide the information required' (ibid: 6). Thus Grade 4 and 5 level items were also used for the development of the Grade 6 test.

The 'Grade 6' test items were first piloted in the Northern Province, where learners had performed at far lower levels than learners in the provinces of Western Cape or Gauteng in the TIMSS and MLA Survey (Seekings, 2001a: 94). Because very few learners still 'obtained enough correct answers in the pilot study to describe variance in ability', a number of Grade 2 and 3 items were also added to the test. This revised 'Grade 6' test was subsequently 'administered in 36 schools in the Northern Province and 70 schools in the Eastern Cape' and in at least 12 schools in the Western Cape (Joint Education Trust, 2001: 5/6). This further testing confirmed that large numbers of grade 6 learners in South Africa are performing far below their grade level³⁶ and fail to get onto the range for this level.

The tests are organized into four sections: numbers, computations, measurement, and fractions and ratios. The items test generic content that should be 'common' across mathematics classrooms. Items in the 'numbers' section cover the structure of the number line, comparing and ordering, structuring of numbers, and rounding off. Items in the 'computation' section cover addition, subtraction, multiplication, division, and combinations of different computations. Items in the 'measurement' section cover length and perimeter, surface area, volume/capacity, weight/mass, geometry (space and shape), clock and calendar, and money (Joint Education Trust, 2001: 6).

One hundred and sixteen of the test items were used for the present study. Ninety eight of the test items used in the present study consist of word or 'real world' application problems and eighteen of the items used consist of pure arithmetic problems. One hundred and six of the items used are in open-response format (where learners are required to write their own answers) and ten items are multiple choice items where learners have 4 or 5 choices of which only one is the best or correct answer. These tests were selected for use in the study because

³⁶ In Chapter1, I pointed out that a number of other large scale studies have similarly revealed that in South Africa learners' performance barely registers on tests benchmarked at what learners were expected to know by the end of a particular grade.

- the test items had external validity in that they reflected generic content that should be 'common' across mathematics classrooms. Teachers and others familiar with the South Africa school contexts had been used to moderate the test items;
- the items represent formal maths topic or sub-topics that are likely to be taught by Intermediate Phase teachers in South Africa;
- the tests are easy to administer effectively and efficiently;
- they had been piloted and used in research projects in a variety of South African contexts;
- they are available in English and Afrikaans - the two 'official' languages of instruction at the sample of schools³⁷;
- permission to use the items was obtained from the Joint Education Trust at no cost on condition that the test items remained confidential and were not published (For this reason a copy of the test cannot be included in the Appendices of this thesis).

Table 9 in Appendix 2 illustrates the distribution of the test items selected across the new curriculum statement outcomes for the numeracy and mathematics Learning Area.

3.1.2 Data collection

The standardised tests were administered as near as possible to the beginning and end of the academic school year. Learners wrote the same pre- and post- test. I provided schools and teachers with a provisional timetable of testing times and dates prior to the testing and confirmed the exact dates and times of the test administration once schools had agreed that these were suitable. I then made the necessary logistical arrangements with individual schools and teachers prior to the actual testing dates. Pre-tests were administered as early as possible in the first term between Monday 3 and Monday 10 February 2003 to a random sample of 30 learners (unless there were fewer than 30 learners) in a class. Post-tests were administered as near as possible to the end of the third term between Monday 15 and Tuesday 24 September 2003.³⁸ A total of 1 164 learners wrote the pre-tests and a total of 1 001 learners wrote both the pre- and post-tests. 446 (45%) of the achieved sample of 1 001 learners wrote the English version of the test and 555 (55%) wrote the Afrikaans version.

³⁷ IsiXhosa or SeSotho (the home language of some learners in the sample) versions of the tests were not available.

³⁸ To comply with WCED conditions for carrying out the research, testing could not take place in the final term.

Eleven test administrators were thus engaged to administer the tests. I was involved in training the administrators, conducting quality control monitoring at schools, observing test administration during the testing periods, ensuring that tests were administered in compliance with the standardised procedures, and carefully controlling the distribution, receipt and return of all copies of tests and test administration documentation.

The test administrators received training in administering the pre- and post-tests at two one day orientation courses. I held training sessions on administering and marking the pre-tests on 22 January 2003 (before the administration of the pre-tests) and 8 September 2003 (before the post-tests were administered). Almost all of the test administrators had already received training in administering these particular tests for other research projects. Nevertheless, training for this study included

- an overview of administrator's role, responsibilities and tasks;
- instructions for school visits and administering the tests;
- instructions on marking the tests.

I emphasised that it was imperative that

- the tests and the test results remain confidential;
- the schools and teachers must not have any access to the tests as this would contaminate data and results;
- uniformity of test administration was crucial to ensure comparable data collection at each site.

In case the format of the items was unfamiliar to learners, test administrators were told to use the examples provided on the test sheets to explain the various item formats, for example, how multiple choice formats differed from open-response formats. Test administrators were also provided with adapted versions of JET manuals which provided the standardised data collection instructions and procedures to be adopted for administering the pre- and post-tests such as the amounts of time allocated for each section of the test (see Appendix 2). The administrators were also required to complete a questionnaire (adapted from TIMSS) after each testing session (see Appendix 3). The primary purpose of the questionnaire was to establish whether any deviations from the prescribed procedures or timing had been made.

As far as I could ascertain through my monitoring of the test administration the tests were all administered in compliance with the standardised procedures.

Test administrators also marked the items using the marking memo provided. I conducted quality control moderating of sub-samples of marked tests from each class. Learners scored one point for each correct answer and zero for incorrect or missing answers. Pre- and post-test results were initially entered on an Excel spreadsheet by the data capture section of the University of Cape Town's Information and Technology Services. Throughout the process, I double-checked all data.

Difference in mean achievement between the pre- and post-test was used to measure achievement gain at the level of individual learners.

3.2 'Opportunity-to-Learn'

The intention of this study is not to assess whether schools or teachers are meeting some kind of standard or whether they are providing learners with the opportunity to learn that which is assessed (TCO or 'a Fair Test measure') (Schmidt *et al.*, 1996; Porter & Smithson, 2001; Rowan, 2002). As explained in Chapter 2, the curriculum in-use in schools in South Africa in 2003 did not express common mathematics content for all schools. The intended opportunities are not codified in a national curriculum as they are now. Although my interest is in the implemented curriculum - that is, the opportunities learners actually have - the OTL research concern of this study is not about 'passing judgment' on how close the content in the enacted curriculum is to the content in the intended curriculum. Rather, the OTL research concern is whether there is a relationship between OTL and achievement gain. It is about establishing naturally occurring variations in learners' opportunity to learn school mathematics.

'Opportunity to Learn' is defined as a four dimensional construct for the study. The four composite OTL dimensions compiled from the literature review in Chapter 2 are

- Content coverage by cognitive demand;
- Content exposure;
- Curricular coherence; and
- Curricular pacing.

In section 2.3 of this chapter, I explained that the analysis evaluates the effects of class level measures of OTL on individual achievement gain with the exception of one individual level measure - data on the number of days absent. Every learner in the same class received the same value for all the OTL measures with the exception of individual level data on the number of days each learner was absent.

3.2.1 Content coverage by cognitive demand

Content coverage

The idea of a potential common curriculum detailing goals at the level of the intended curriculum for each grade is central to the notion of measuring OTL, in particular the 'content coverage' aspect of 'content coverage by cognitive demand' (refer section 1.1.1 of Chapter 2). The first requirement for measuring 'content coverage' was, by necessity, the construction of a 'framework of potential curriculum content' that ensured that data collected across classes were comparable (Porter & Smithson, 2001; Rowan, 2002).

As elaborated on in chapters 2 and 3, the official curriculum document in-use in schools in South Africa in 2003, in other words, the 1997 version of Curriculum 2005, did not express the core content, skills and concepts learners are expected cover in the Numeracy and mathematics Learning area at each grade level. Hence it was not possible to use the curriculum in-use as a framework for establishing variations in learners' opportunity to learn school mathematics contents as has been done in other studies of OTL where the curriculum is specified (Porter & Smithson, 2001).

I had therefore to construct a framework first. I decided to use the RNCS for the numeracy and mathematics Learning Area as the primary tool for constructing a Framework of Potential Curriculum Content and for categorizing 'pieces' of the Framework into the smallest elements possible. Although this was not the curriculum in-use in 2003, the assumption underpinning this decision was that the new statements were most likely to reflect what was currently considered to count as worthwhile mathematics knowledge for learners in South Africa (see Chapter 3).

The document I used for constructing the Framework for measuring 'content coverage' was the Department of Education's Revised National Curriculum Statements Grade R-9:

Mathematics May 2002. The mathematics Learning Area Statements in the RNCS documents list minimum assessment standards per outcome per grade, and the assessment standards provide a guide to the content, concepts and skills that are considered essential for school mathematics for each grade in each phase.

A further assumption underpinning the construction of the Framework is that, because many South African grade 6 learners are performing at lower levels than their grade requirements (Joint Education Trust, 2001; Seeking, 2001a), teachers have to address gaps in learner knowledge and skills whilst trying to cover mathematics content at the grade 6 level. In other words, because learners are under-prepared and may not have adequately mastered Maths content, concepts and skills essential for studying more advanced work, an expectation was that teachers were likely to also cover or review content, skills and concepts that learners should have covered at the grade 4 and 5 level. Thus, in order to assess learners' OTL more judiciously and accurately, the Framework of Potential Curriculum Content had to at least include curriculum content outlined for the Intermediate Phase as a whole (grade 4-6) rather than only at grade 6.

The main categories for constructing the Framework of Potential Curricular Content for the study comprise the five learning outcomes (LO) for the numeracy and mathematics Learning Area. Within each LO the assessment standards are organized into a number of 'clusters'. Table 10 in Appendix 4 from page 2.11 from draft number 2 of the Mathematics Learning Programme Policy Guidelines/MLPPG (NDoE, nd) shows 'clusterings' or sub-topics for outcomes in the Intermediate Phase.

The idea was to make the Framework as specific as possible in terms of content complexity so as to capture the most finely grained elements of each outcome or content 'cluster' covered and allow for specific analysis of content covered rather than simply broad patterns of differences in mathematics content coverage. For the purposes of the research, the Framework of Potential Curriculum Content has been constructed so that each curriculum 'cluster' is described in terms of the most finely grained detail possible so that data on specific elements of content covered could be collected.

For example, the Framework describes LO1: Number, operations and relationships: Recognizing, classifying and representing numbers: Representing and comparing whole numbers including zero and fractions in the following topic complexity:

Table 11: Example of topic complexity in Framework of Potential Curriculum Content

Representing and comparing whole numbers including zero and fractions including:	
	Whole numbers to
11	4-digit numbers (g4)
12	6-digit numbers (g5)
13	9-digit numbers (g6)
14	Odd and even number to 1 000 (g4)
15	Common fractions in diagrammatic form (g4)
	Common fractions with different denominators including
16	halves (g4)
17	thirds (g4)
18	quarters (g4)
19	fifths (g4)
20	sixths (g4)
21	sevenths (g4)
22	eighths (g4)
23	tenths (g6)
24	twelfths (g5, 6)
25	hundreds (g6)

G4, g5, g6 indicates that these units or elements are considered essential at the grade 4, 5 or 6 level – in other words, they reflect work that learners are, at a minimum, expected to cover at this level. However, although certain elements of topics or sub-topics are considered essential for a particular grade level (for example, element number 11, 12 and 13 above), there are other elements of topics or sub-topics that are considered essential at all intermediate grade levels, for example elements numbered 48, 49 and 50 on Table 12 below.

Table 12: Example of grade levels in the Framework of Potential Curriculum Content

	Using operations appropriate to solving problems involving:
	Rounding off to the nearest
48	10 (g4,5,6)
49	100 (g4,5,6)
50	1 000 (g4,5,6)

Although the RNCS include ‘issue- or value-based’ element such as ‘Describing and illustrating various ways of counting in different cultures (including local) throughout history’ (LO1 Intermediate Phase), for the purposes of the study the majority of issue-/value-based topics were not included on the Framework of Potential Curriculum Content as I selected those topics that are more distinctively school knowledge and contents that are ‘unlikely to be learned outside school’ or in other Learning Areas (Floden, 2003: 257). I also wanted to focus on sub-topics that are most aligned to features of the test items used.

Once the outline of the Framework had been drafted and the grade levels indicated, a mathematics curriculum expert was asked to verify the grade level information on the Framework by indicating which of the elements related most specifically to minimum grade 6 level expectations. Thus the shaded numbers above indicate that elements are ‘pieces’ of the ‘minimum’ intended grade 6 curriculum. What is important is that the Framework of Potential Curriculum Content is constructed so as to make it possible to capture ‘content coverage’ at the most specific grade and content levels and to describe curricular variations in macro pacing across classes in terms of content complexity.

Content emphasis

The second dimension of content coverage is ‘content emphasis’; or the estimated number of single mathematics lessons or periods spent on each element of the Framework (see section 1.1.1 of Chapter 2 - Stevens, 1996; De Haan, 1992; Porter & Smithson, 2001). As stated in Chapter 2, neither the original Curriculum 2005 nor the RNCS for mathematics prescribed or provided indications of the emphasis to be given to the various components of the curriculum in terms of clear guidelines as to how many period teachers should devote to certain contents. Draft number 2 of the MLPPG (NDoE, nd: page 2.9) which was available at the time when

the study was being designed, provided the framework on Table 13 in Appendix 4 for allocating time or emphasis for each of the five outcomes in the Intermediate Phase.³⁹

However, I did not consider the information specific enough for my purposes, as, according to Stevens (1996), what is important is that content emphasis describes whether enough time is spent for thorough teaching of particular topics. In order to establish a more substantial notion of ideal time against which to measure the actual amount of time teachers spent on each element of content outlined in the Framework of Potential Curriculum Content, I asked an experienced and highly competent academic head of intermediate phase mathematics at a high-performing school to indicate the amount of time in terms of the number of single 30 minute periods she would ideally devote to each of element of the Framework shaded as essential at the grade 6 level. She was asked to indicate topic emphasis over a school year *as if* the Framework was the intermediate phase curriculum in-use. In the absence of expressed expectations of content emphasis in the NCS or Guidelines, the idea was to have a more refined ideal notion of the amount of time teachers could be expected to spend on topics so that the estimated amount of time teachers in the study actually spent on the various elements could be compared to this ideal notion. For example, Table 14 shows her ideal notions of ‘content emphasis’ for some of the grade 6 level elements of LO 5 – Data handling. ‘Ideal’ is used in a modified way as ideal for teachers in middle class schools may not really be ideal for teachers working in very different contexts.

³⁹ Although later versions of the Guidelines have since replaced this document, when the study was being designed, this was the most recent document I could access and is not too dissimilar to more recent revised documents. However, this information appears to have been dropped from subsequent documents. (The above guidelines may have been perceived as being ‘too prescriptive’.)

Table 14: Notion of ideal time in the Framework of Potential Curriculum Content

<i>SECTION 5: DATA HANDLING:</i>		
5.1 COLLECTING AND ORGANISING DATA	Ideal time:	
	<i>Number of single 30 min periods</i>	
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment (g4, 5, 6)		
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners (g5, 6)		
Using tallies and tables to organise and record data (g5, 6)		
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:		
the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies (g4, 5, 6)		
the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies (g5, 6)		

* 203, 204 & 205 combined – four periods

Her ideal notion of 'content emphasis' was subsequently validated by two other experienced grade 6 mathematics teachers at relatively high-performing schools who specified where they disagreed and indicated the number of periods they would expect to spend on the particular sub-topics. Variations are indicated on the instrument as, for example, 4-6. This made it possible to compare the estimated actual amount of time teachers in the study spent on the various elements with an ideal notion.

Data collection methods for content coverage and emphasis

In an attempt to standardize data collection procedures, ensure more rigorous data gathering methods and as much uniformity as possible in the collection of data, like Porter & Smithson (2002) and the TIMSS, I developed a highly structured instrument to collect and collate most of the OTL data collected (see Appendix 5)⁴⁰. The first section of this OTL instrument was

⁴⁰ A limitation of using the framework was that this method excludes topics covered that are not included on the framework. Although, the data collection instrument included a section where data collectors could note any other mathematics subject matter that was covered not listed on the framework, this additional data was not included in the final analysis.

used to standardize the capture of ‘content coverage’ and ‘content emphasis.’ The Framework of Potential Curriculum Content was used to identify the topics or sub-topics covered and the estimated number of lessons spent on each topic/sub-topic covered in each of the three terms. As classes sometimes cover a number of topics in one lesson, the instrument also makes provision for estimates of less than one lesson as is illustrated in the following extract of the grade 6 instrument:

Figure 1: Extract from Grade 6 Curriculum Coverage, Exposure, Coherence and Pacing Instrument

SECTION 2: MEASUREMENT				
	Covered	Ideal time	Estimated number of lessons	
		Number of single 30 min periods	Tick if less than one	If one or more, estimate how many (write a number)
2.1 TIME	Tick if yes			
Reading and writing analogue, digital and 24-hour time including:				
Analogue time (time read from a clock with a face and hands)				
92	to the nearest minute (g4,5,6)			
93	to the nearest second. (g4,5,6)			
Digital time (time read from a clock that has a continually changing digit display rather than a clock face)				
94	to the nearest minute (g4,5,6)			
95	to the nearest second. (g4,5,6)			
24-hour time				
	to the nearest minute (g4,5,6)	2		
	to the nearest second. (g4,5,6)	2		

In a large-scale study the use of teacher judgment is usually the most direct approach for measuring ‘what is taught’ in each grade and the amount of time given to specific mathematics topics (Porter & Smithson, 2001). Unlike most larger-scale studies that employ survey methods, this research mainly relied on information gathered from an examination of the two most comprehensive learners’ workbooks or files in each class at the end of each of the first three terms. Three other methods were also used as supplementary sources for triangulation.

A highly structured teachers survey interview schedule closely based on the OTL instrument which included the Framework of Potential Curriculum Content was also used to collect teacher self-report data on the contents covered in grade 6 in each class in each of the first three terms (see Appendix 6). The second supplementary method entailed an examination of teacher’s year or term plans. The third supplementary method used included an examination of learner’s reports on the daily content of their instruction for the year. At the beginning of

the year two learners in each class were asked and given incentives in the form of gift vouchers each term to keep diaries on the daily content of their lessons for the year. These were examined at the end of each term.

The reason for mainly relying on information from learners' workbooks is that, even in developed country contexts, self-report data alone is not always considered sufficiently reliable (McDonnell, 1995; Ball *et al.* 1999; and Mayer, 1999 in Floden, 2003). As stated in Chapter 2, in South Africa, the PEI report (Taylor & Vinjevold, 1999) reported that studies showed disparities between what teachers actually did and what they said they did in classrooms in terms of classroom practices. In South Africa, we have little research on levels of agreement between teachers' and researchers' reports of information on the content of instruction. As the focus of my study was on the mathematics actually covered, rather than the planned coverage, I decided to use the examination of teachers' year plans or schemes of work, together with the interviews, primarily to orientate the data collector as to what could be expected to be found in learners' workbooks before examining them.

The following routine was built into the data collection procedures. Once teachers had been interviewed and their year or term plans examined⁴¹, the records of work in the two workbooks were closely checked against the Framework of Potential Curriculum Content to determine whether teachers had actually covered possible topics or sub-topics. Teachers' reports in the interviews and learners' reports in the diaries were used in instances where it was not clear whether or not teachers had covered topics or sub-topics and there was unlikely to be any readily observable information in the primary sources (workbooks) but teachers and/or learners reported covering them in the interviews or diaries, and the data collector judged the self-report data sufficiently reliable to make it reasonable to assume that sub-topics had been covered. In these cases, the assumption was made that the sub-topic had been covered. The idea was to use the multiple data collection methods and sources to ensure greater reliability and establish and sort out discrepancies in the data collected.

As WCED approval to conduct the research was granted on conditions that the data collection was not conducted during the fourth term (quarter), data collection took place in the first three terms of the academic school year. Data on 'content coverage' and 'emphasis' was

⁴¹ Year/term plans were not always readily available.

collected towards the end of each quarter for the first three terms rather than 'once off' towards the end of the school year. This routine was built into the data collection procedures as it was relatively easier to obtain information about the content covered each term and this was considered to be more feasible and reliable or accurate. Data collectors used the Framework on the Curriculum Coverage, Exposure, Coherence and Pacing Instrument first to indicate whether or not a sub-topic had been covered, in other words simply to indicate the presence or absence of evidence that a sub-topic had been covered, and then to estimate the amount of time actually devoted to a sub-topic in terms of 30 minute periods (in other words, to estimate the relative emphasis given to a topic). Whilst the specific number of sub-topics and lessons spent on them may not be precise, I believe they are fairly reliable estimates of coverage and emphasis. The 'content emphasis' data are used in the descriptive analysis.

For the statistical analysis of the variable 'content coverage', the model used was a simple count of 'whether or not', for example, there was evidence that each of the possible 221 Intermediate Phase sub-topics on the Framework had been taught in the first three terms of 2003. This dimension was measured in terms of presence or absence of evidence rather than in terms of the amount of time actually devoted to the topic (in other words, the relative emphasis given to a topic).

Cognitive demand

Content coverage in the study relates both to the mathematics content covered and to the cognitive level at which the content was covered (see Porter & Smithson, 2001; Gamoran, Porter, Smithson, & White, 1997 in section 1.1.1 of Chapter 2). In Chapter 2, I pointed out that, as far as the 'cognitive level' dimension of the 'content by cognitive demand' variable is concerned, the original South African curriculum documents do not specify the cognitive levels at which learners are expected to engage with mathematics. However, the RNCS and Draft number 2 of the MLPPG do make more general statements that, whilst 'drill and practice' and 'following worked examples' are important (NDoE, nd: 2.4), learners are also to be 'given opportunities to develop a deep and coherent conceptual understanding of mathematics' (ibid: 2.5). The documents express the expectation that learners will be engaged with procedural knowledge as well as underlying mathematical principles and concepts.

As there was not necessarily an obvious hierarchy between the categories of cognitive demand distinguished in most of the studies reviewed in Chapter 2, and as content complexity also forms an important dimension of cognitive demand, I developed the following five content and cognitive complexity levels on a matrix (Porter & Smithson, 2001) to establish variations in learners' cognitive levels of engagement with mathematics content. A scale from 1-5 was used to rate levels of cognitive demand on a two dimensional rubric of:

- a) low (1) – high (5) content levels (grade level content complexity): and
- b) low (1) – high (5) cognitive levels (cognitive complexity)

The matrix of content and cognitive complexity levels can be seen on the observation schedule in Appendix 10. A rating of 1 or 2 for cognitive level indicates that learners are not engaged with specialized mathematics knowledge. Ratings 3-5 involve engagement with specialized mathematics knowledge. Ratings of 4 or 5 involve the reasoning or principles behind the use of specialized mathematics knowledge.

Data collection methods for cognitive demand

It was hoped that learner workbooks could be used to establish the cognitive levels at which the various contents were covered (what learners were expected to do with these contents) so that this could be recorded alongside each element of the Framework on the Curriculum Coverage, Exposure, Coherence and Pacing Instrument (see Porter & Smithson, 2001 in section 1.2.1 of Chapter 2). However, pilot work showed that it was not possible to reconstruct the cognitive level at which topics were covered or to collect reliable data on levels of cognitive demand using learner workbooks and other supplementary sources. Data in these sources were simply not adequate enough mainly because actual worksheets or textbook material used were not usually available. A more direct method of data collection was required.

Data on this dimension of content by cognitive demand were established by using data from the three lesson observations of each of the 38 classes which took place in the first, second and third term (see 3.3.1 of this chapter for details of the lesson observations and Appendix 7 for a copy of the observation schedule). Although the focus of the observations was on collecting data on teachers' preferred pedagogical approaches, cognitive demand in each of the three observed lessons was rated in relation to the grade level of the content covered (content complexity) in the particular lesson and the five cognitive levels (cognitive

complexity) specified above. Content complexity was determined by referring to the Framework of Potential Curriculum Content on the Curriculum Coverage, Exposure, Coherence and Pacing Instrument.

Ratings for content and cognitive levels for each of the three lessons observed were combined to establish a single quantitative measure of levels of cognitive demand for each class. This made it possible to differentiate, for example, between engagement with mathematics procedures and principles (rated as 5) involving grade 6 content (rated as 4, i.e. $5 + 4$) as opposed to engagement with mathematics procedures and principles (rated as 5) involving grade 4 level content (rated as 2, i.e. $5 + 2$). The combined content and cognitive complexity level rating for all three lesson observations was used as a single quantitative measure of the 'cognitive demand' dimension of 'content coverage by cognitive demand.' The maximum rating for cognitive demand for a class was thus 30 whilst the minimum was 6.

Exposure to word problems

A component of the 'content coverage by cognitive demand' variable that was considered important to include in this particular study was learners' levels of exposure to word-problems. Although 'solving word problems' or 'applications of mathematics in real situations' is frequently cited as one of the distinctions of cognitive demands in studies (see for example, Thompson & Senk, 2001, Gamoran, Porter, Smithson & White, 1997 in section 1.1.1 of Chapter 2), it seemed that there is no obvious hierarchy between the categories of procedures, properties or 'the principles behind the mathematics' and 'applications of mathematics in real situations'. For example, it is possible for learners to be engaged in word problems at procedural levels without being engaged at principled levels. For this reason and reasons outlined in the following paragraph, unlike other studies, I have treated 'exposure to word problems' as a dimension of content coverage and not as a category of cognitive demand.

South African studies have shown that learners experience difficulty in answering word problems and in reading and understanding test items (Taylor & Vinjevoild, 1999b; Taylor *et al.*, 2003). Not only are learners' efforts often hampered by low reading levels and inadequate language skills (particularly when the medium of instruction and testing is not learners' primary language but their second/third language), but also because they do not have strategies for tackling mathematics word problems and are unsure about how to proceed.

A number of classroom-based studies conducted in South Africa have shown that learners in many classrooms are given few opportunities to read (Taylor & Vinjevold, 1999b). The view is that learners are more likely to answer correctly if they are frequently exposed to word problems (Cooley & Leinhardt, 1980).

Data collection methods for exposure to word problems

Originally my intention had been to use the learner workbooks to establish whether learners were being exposed to word problems involving the applications of the various mathematics contents covered and to record this information alongside each element of the Framework on the Curriculum Coverage, Exposure, Coherence and Pacing Instrument. However, pilot work in the first term of 2003 showed that it was not possible to collect reliable data using the learner workbooks and other supplementary sources as the information available in the sources was simply not adequate enough. The sources did not provide a clear enough indication as to whether tasks had involved word problems or not mainly because actual worksheets or textbook material used were not usually included.

Although the focus of three lesson observations that took place in the first, second and third term was on collecting data on teachers' preferred pedagogical approaches (see section 3.3), data from the lesson observations were also used to obtain a proxy measure of learners' exposure to real world word problems. Evidence of applications of mathematical knowledge in real world word problems was recorded on the classroom observation schedule (see Appendix 10). Ultimately, the measure of learners' exposure to word problems used for the study was based on the number of lessons in which engagement with word problems was evident. The following 4-point scale was used: 0 = none; 1 = 1 lesson; 2 = 2 lessons; 3 = 3 lessons.

3.2.2 Content exposure

'Content exposure' is a measure of the estimated total amount of time actually spent engaged with mathematics content as opposed to the amount of time allocated for mathematics instruction (see Carroll, 1963; Wang, 1998 in section 1.1.2 of Chapter 2). At the beginning of the year copies of the mathematics timetables of each of the grade 6 classes participating in the study were collected to ascertain the number of lessons allocated for mathematics instruction for each class. The idea was that the absolute amount of time spent on mathematics could be measured by correlating dates in the learner workbooks and the

information in learners' diaries with the number of mathematics periods allocated on the timetables to establish the number of lessons that classes had missed.

The timetables showed class periods as typically 30-45 minutes. However, when lesson observations were conducted in the first term, it became apparent that many teachers were not sticking to the scheduled times on the timetable for mathematics instruction, particularly class teachers who were not mathematics subject teachers but who taught all or most subjects to one grade 6 class. Not only was there evidence of mathematics lessons taking place at times officially allocated for other Learning Areas (LAs), there was evidence of mathematics lessons extending across a number of lessons allocated for different LAs. Teachers were observed teaching mathematics in 'sessions' rather than periods, for example, some classes received maths instruction from the beginning of the first period of the day until the end of the period before little break, for example over 4 periods, even though some of the periods were officially allocated for other subjects. In some cases, mathematics instruction even continued after first break until lunch break and beyond. It seemed that some teachers were using time for other LAs as 'a repair system' for mathematics. Whilst this could be a response to the WCED's systemic evaluation of grade 6 learners' mathematics performance which commenced in 2003 what is clear is that, in these classes, mathematics instruction was being prioritized over instruction in other Learning Areas and that the status of mathematics was higher than that of the other LAs⁴². By implication official timetables could not be used as a reliable measure of the total amount of time available for mathematics instruction because individual teachers were allocating time differently.

On the other hand, data from other research projects and evaluation studies (see for example, Bateson, 1994; Schollar, 1995; Taylor & Vinjevoold, 1999a) and lesson observations for the study showed evidence of organisational factors at schools contributing to time-off-task and there were incidences when time allocated for mathematics instruction was used for non-curricular activities, for example, morning assembly extending into time allocated for curricular instruction. More importantly, however, micro pacing within a number of lessons appeared to be extremely slow (see Chapter 6 section 1.1). By implication, although more than the allocated number of periods was spent on mathematics instruction in a day, very little work might be reflected in learners' workbooks because of the slow work rate in class.

⁴² In one case, the teacher made learners who had not completed class work continue with mathematics tasks during break.

For the above reasons and for the purposes of comparison in the study, this 'time on task' or 'academically engaged time' dimension was measured in terms of three variables:

- a) the number of pages of work in the two most comprehensive of learner's workbooks in each class by the end of the third term (Good, Grows & Beckerman in Rosenshine & Berliner, 1978; Lee, 1982),
- b) the number of days each learner was absent as reflected in class attendance registers (Lee, 1982; Reimers, 1993; Wang, 1998), and
- c) the extent to which all learners in each class were equally engaged with mathematics in the three observed lessons (Berliner *et al.*, 1978 in Floden, 2003; Lee, 1982).

Unlike the other dimension of the OTL construct, the 'time on task' dimension was measured using a combination of class-level and individual learner-level time variables. The idea was that including both learner level OTL and multidimensional class level OTL would avoid bias and hopefully more accurately provide estimates of effects.

The rationale for using the number of pages of work in learners' workbooks was that this reflected time on task in terms of 'opportunities to practice' or time spent overall on mathematics work. The assumption here is that 'content exposure' is the same for all learners in a class. The rationale for including individual learners' attendance rates was that learners who are absent more often than others have less exposure to mathematics content than their classmates even though they are in the same class. The idea is that individual levels of absenteeism reflect differences in time spent in mathematics classes.

The reason for including data on the extent of learner engagement within observed lessons was to attempt to counter-balance the fact that the workbooks used for data collection of a) were the 'most comprehensive' books. Data were therefore likely to represent the most mathematically-engaged learners who paid attention and completed tasks in class, whilst other learners may have been observably less engaged in mathematics activities in class. For this reason I decided that it was not sufficient to gauge the degree of learners' 'content exposure' in the same classes using only the number of pages of work in the two workbooks examined. I chose to include a measure of learner engagement in lessons in the measurement of 'content exposure' to show where there appeared to be variation in individual learner participation/ engagement within the same class.

Clearly estimating the degree of learner engagement in lessons is difficult (Dewey, 1904/1965 in Floden, 2003). However, the idea was to get a general indication as to whether some learners were noticeably off task and engaged in activities that had nothing to do with the mathematics knowledge they were expected to learn and the main tasks they were expected to complete. To capture this, I used a 4-point scale to rate levels of academic engagement of the entire class across the three lessons observations. The measure of engagement in mathematics lessons used for the study was based on the number of lesson observations in which learners were reportedly paying attention and/or doing the required mathematics work. A 4-point scale was used: 0 = none; 1 = 1 lesson; 2 = 2 lessons; 3 = 3 lessons. The scale to rate levels of 'engagement' can be found on Table 15 in Appendix 7.

The rating for all three lesson observations was used as a quantitative measure of the extent to which learners in each class were apparently equally engaged in mathematics lessons.

Data collection methods for content exposure

Learner absenteeism

School records of learner attendance were used for gathering the information on learner absenteeism. Class registers were examined before the end of each of the first three terms when other OTL data was collected. This was not always without its difficulties. On the one hand, it was not possible to get a complete set of data for all the classes. In one class no data was available at all because the teacher never provided her register in any of the three terms. Another teacher lost her register during the course of the year so records of absenteeism for the entire class in the second term could not be captured. In other cases, the reliability of the information in some registers seemed questionable. For example, one teacher apparently did not keep his own records and was witnessed asking learners to report on the number of days they remembered being absent at the end of the term.

In other classes, data collection in subsequent terms revealed that teachers' final tallies which were written in ink at the end of the previous term differed from the information captured for the study by counting the number of days each learner was marked 'absent' when data was collected two weeks prior to the end of the term before teachers made their final tallies. Daily records of learner absenteeism which had originally been written in pencil appeared to have been altered. In the end I used the 'official' data from the registers on the premise that even if data on the number of days each learner absent was not exact, the information should

at least indicate higher levels of individual absenteeism, and indicate which learners had missed the most mathematics lessons.

The number of pages of work in learner workbooks

'Content exposure' data using the number of pages of work in the two most comprehensive of learners' workbooks were similarly collected at the end of each term for the first three terms. At the end of the second term, I also collected and kept the two workbooks from each class for the mid-year holidays in June/July 2003. During this time I cross-checked the data collected on the pages of work in the books from the first two terms by comparing the amount of work across classes before the books were returned to all the schools at the start of the third term.

Learner engagement

Data on levels of learner engagement were established by using data from three lesson observations of each class which took place in the first, second and third term (see 3.3.1 in this chapter for details of the lesson observations – a copy of the observation schedule is provided in Appendix 10).

3.2.3 Curricular coherence

'Curricular coherence' is a measure of the internal coherence of the sequencing of curriculum content (see Schmidt *et al.*, 1996; Smith, Smith & Bryk, 1998 in section 1.2.2 of Chapter 2). In Chapter 2, I pointed out that the empirical evidence in South Africa is that the trend is for grade level teachers to use the same teaching schemes or plans. There is little evidence that such schools use 'differentiated curricula' within grades. Hence a more relevant measure of 'curricular coherence' in the current South African context is the extent to which grade 6 mathematics content and topics are presented in a logical and sequential order across the academic school year in terms of developmental complexity.

Neither the RNCS nor Draft number 2 of the MLPPG provided the order in which curricular topics are intended to be sequenced and organized within each grade. However, the Guidelines do state that 'time should not be allocated to the Learning Outcomes on a once a year basis but rather a number of time allocations per year as the knowledge and skills developed in one outcome compliment the knowledge and skills to be developed in another' (NDoE, nd: 2.10). The document also states that 'there is no single best organization of the

Learning Outcomes into time slots or sequencing of the units of work' (ibid: 4.16). In other words, there can be considerable variation or diversity in topic sequencing in different classes. Topics and sub-topics can be introduced, dropped and receive attention again at different times in different terms. As there is no unique sequence or logic for the presentation of topics and sub-topics, the expectation was that there would be sequence variations in the order or sequence in which topics and sub-topics were covered across the grade 6 classes. Disciplinary expertise would thus be required to exercise judgment over levels of 'content coherence.'

Data collection methods for 'curricular coherence'

As far as the variable 'curricular coherence' was concerned, initially my plan was to use the Framework of Potential Curriculum Content in the first section of the Grade 6 Mathematics Curriculum Coverage, Exposure, Coherence and Pacing Instrument to indicate the order in which the topics or sub-topics were covered by writing the sequence number next to each topic covered. However, pilot work in the first term of 2003 showed that this method was too complicated and time consuming. Instead the method used was to map the content sequence directly from the two most comprehensive of learners' workbooks and use the two learner diaries, the teacher interview and term or year plan as supplementary data sources. The idea was to try to provide the most in-depth information possible (in line with the 'grain level detail' of the Framework of Potential Curriculum Content, for example, 'multiplication of 2 digit by 2 digit whole numbers, rather than simply outline broad topics, for example, as 'multiplication'). Data on content sequence was also collected at the end of each term for the first three terms rather than 'once off' towards the end of the school year.⁴³

Expert opinion data was used to analyse the data collected. A mathematics curriculum expert was asked to examine the data collected on the order or sequence in which mathematics contents were covered across the first three terms of 2003 and to use disciplinary principles to determine whether learners studied mathematics topics and sub-topics in an appropriate sequence. This person was on the committee for the RNCS for the Numeracy and mathematics LA. The curriculum expert exercised her judgment in assessing or making an

⁴³ One of the limitations of not using section one of the Grade 6 Mathematics Curriculum Coverage, Exposure, Coherence and Pacing Instrument to capture data was that data collection on this variable was not as systematic and standardised as I had hoped. Although the plan was to write down topics in line with the 'grain level detail' of the Framework of Potential Curriculum Content, sometimes too little information was captured making data on this variable a little uneven.

estimation of low, medium or high levels of 'curricular coherence'. She provided two kinds of information. First she assessed coherence in terms of topic sequence and then in terms of topic spread across the three school terms. A 3-point scale was used to rate levels of curricular coherence on a two dimensional matrix which can be seen on Table 16 in Appendix 7.

The combined ratings of sequence and spread were used as quantitative measures of variations in levels of 'curricular coherence' for learners in each class.

3.2.4 Curricular pacing

'Curricular pacing' is a measure of each school's structuring or pacing of curriculum across adjacent grades, that is, across grade developmental complexity (see Smith, Smith & Bryk, 1998 in section 1.2.1 of Chapter 2). The idea is that 'curricular pacing' provides a proxy measure of learners' curriculum exposure to other teachers in previous years and that 'curricular pacing' helps prevent a cumulative deficit in breadth and depth of domain-specific knowledge. In the study pacing across the Intermediate Phase grade adjacent to grade 6 was measured to determine whether or not there was conceptual advancement in mathematics content from grade 5 to 6. In other words, data collected on content coverage and emphasis in grade 5 and 6 was used to establish a proxy measure of a curricular pacing trajectory for learners in each class tested. The assumption is that data collected on content coverage at schools in grade 5 in 2003 reasonably reflects the content coverage that the sample of grade 6 learners at the schools would have experienced the previous year in grade 5.

Data on mathematics 'content coverage' and 'content emphasis' (the number of lessons spent on each of the topics or sub-topics) for grade 5 was collected at each school through the use of a Curriculum Pacing Instrument developed for grade 5 (see Appendix 8) This instrument used the same Intermediate Phase Framework of Potential Curriculum Content developed for the Grade 6 Curriculum Coverage, Exposure, Coherence and Pacing Instrument but the instrument was constructed so that the focus was on grade 5 content coverage and emphasis. Shaded numbers on the grade 5 instrument indicate that elements are 'pieces' of the grade 5 curriculum (the mathematics curriculum expert was asked to indicate which of the elements related to grade 5 level expectations) and, an ideal notion of 'content emphasis' for the grade 5 elements of the Framework are provided. The academic head of intermediate phase mathematics at the high-performing school was asked to indicate the amount of 30 minutes

lessons she would ‘ideally’ devote to each of the essential grade 5 level elements. Her ideal notion of ‘content emphasis’ was validated by two other experienced grade 5 mathematics teachers at other high-performing schools.

Figure 2: Extract from Grade 5 Curriculum Pacing Instrument

	Covered	Estimated number of lessons	Ideal number single 30 min periods
	Tick if yes	Tick if less than one If one or more, estimate how many (write a number)	
1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS			
Counting including:			
Counting forwards and backwards in:			
1 2s (g4.5)			
2 3s (g4.5)			
3 5s (g4.5)			
10s (g4.5)			1
25s (g4.5)			1
50s (g4.5)			1
100s (g4.5)			1
a variety of whole number intervals between 0 and 10 000 (g4.5)			1
fractions (g5)			1
decimals (g5)			

Methods for data collection again included an interview, this time with grade 5 teachers, that entailed using a highly structured schedule about the topics and sub-topics covered and the estimated number of lessons spent on each topic or sub-topic (see Appendix 9 for the grade 5 teacher interview schedule). Other methods involved an examination of grade 5 teachers’ term or year plans or schemes of work; and an examination of the two most comprehensive of the learners’ workbooks. However, the workbooks were the main source used to determine whether ‘content coverage’ and ‘content emphasis’ for each grade 5 class was below, consistent with or above expected levels for the grade, whilst the two other methods were used as supplementary sources for triangulation.

Data collection methods for curricular pacing

‘Curricular pacing’ data was collected at the end of each term for the first three terms.

The following routine was built into the grade 5 data collection procedures. At the end of the first term of 2003, an interview was conducted with all (or as many as possible) of the grade 5 mathematics teachers at each school (where there was more than one grade 5 mathematics teacher) to ascertain whether all grade 5 teachers followed the same term/year plan and cover

the same topics across the school year. In all cases, the Grade 5 teacher interviewed reported that they essentially tried to cover the same topics and spend similar amounts of time on topics. This information was followed by an examination of the term/year plans and the two learners' workbooks from each grade 5 class to ascertain the extent of alignment in terms of content coverage and emphasis. Once again, in all cases it appeared that there was sufficient evidence of conformity across grade 5 classes at each school to render it reasonable to collect one set of grade 5 data at each school at the end of each term.

The same routine described under the heading '*Data collection methods for grade 6 content coverage and emphasis*' was then built into the grade 5 data collection procedures using the Grade 5 Curriculum Pacing Instrument.

3.2.5 Data collection

This is a study that attempts to get fairly fine-grained OTL information on a relatively large sample. Data collection involving the grade 5 and 6 teacher interviews, the examination of grade 5 and 6 term or year plans and the most comprehensive of learner workbooks, and an examination of grade 6 learner diaries took place during the last two weeks of each of the first three terms in 2003. The gathering of this data involved 38 grade 6 classes and 24 grade 5 classes in 24 schools spread across 4 districts.

It was not possible for me as a single researcher to carry out the task of conducting 62 interviews with grade 5 and 6 teachers, examining 62 term/year plans, 124 grade 5 and 6 workbooks and 62 learners' diaries in the two week period set before the end of each term. I consequently engaged and trained five post-graduate mathematics students in collecting data with me, providing them with face to face training for one day prior to each of the three data collection periods at the end of each term. I also pre-arranged appointments for data collection at all the schools each term. Data collection for the first term took place over 7 days between 19-27 March 2003. Data collection for the second term took place over 8 days between 17-26 June 2003. Data collection for the third term took place over 10 days between 10-23 September 2003. As far as was possible, each class was allocated a different data collector each term. Not all the data collectors were available for the whole period as they had other work commitments or engagements, nevertheless 1-3 grade 6 and 5 classes were covered per day. Even with five data collectors it was a demanding schedule as data collection could not be done before or after school and teachers were, understandably,

sometimes unwilling to spend their break times being interviewed. (Interviews took place in teachers' classrooms, school libraries, or the staffrooms.)

During each period of data collection I participated in the process and conducted quality assurance visits at schools. In addition, data collectors had to complete the 'checklist' at the end of the Curriculum Coverage, Exposure, Coherence and Pacing Instrument after collecting data on each class (see Appendix 5). All data collected were checked by me. Where I found discrepancies or deficiencies in any of the data, I asked the responsible data collector for clarification. Any unresolved or outstanding details or queries from the first or second term were confirmed or checked when the next round of data was collected the following term. Only once all the data collection for the three terms was completed was the information for all three terms for each class collated, coded and captured onto one form.

3.3 'Type of pedagogy'

Besides testing for the relative effect of OTL on learner achievement, the relative effect of 'type of pedagogy' on learner achievement was also assessed. Variables for 'type of pedagogy' were generated primarily from Bernstein's conceptual framework outlined in Chapter 3. I have also used conceptual categories established by other researchers in similar settings. Drawing on the work done by Morais and Neves (2001), Neves and Afonso (2002); and Morais and Pires (2002), thirteen key variables for the instructional (seven variables) and regulative (six variables) contexts were used to characterize the 'type of pedagogy' observed in lessons. Instead of including all the elements of pedagogy provided in the methodological model used by other researchers, I have selected those elements which are more appropriate for the analysis after taking into account the prevailing pedagogical policy in South Africa.

At the level of the *regulative context* (hierarchical rules), pedagogical practices are assessed in terms of the degree to which

- the boundary between the teacher's and the learners' space is distinct or 'blurred' (the extent to which the organization of pedagogic spaces for teaching and learning de-emphasise the teacher's position of power to facilitate weakly framed social relationships between the teacher and learners);

- the boundary between learners' spaces is distinct or 'blurred' (the extent to which space and seating in the classroom is organised to facilitate weakly framed social relationships between learners and promote learner interaction and collaboration);
- the hierarchical relationship between the teacher and learners is 'masked' or clear (the degree to which the teacher's social status or position of authority and the fact that the teacher defines the characteristics of the instructional and regulative contexts is 'hidden');
- hierarchies between learners are 'masked' or clear (the degree to which learners have equal social status in the pedagogic relation so that possible academic hierarchies between them are 'hidden');
- communication relations between the teacher and learners are opened or closed (the degree to which learners can initiate interaction and control the timing, content and duration of teacher-learner interactions);
- communication relations between learners and their peers are opened or closed (the degree to which learners have opportunities to interact and collaborate with one another).

At the level of the *instructional context* (discursive rules), pedagogical practices are assessed in terms of the degree to which

- the boundary between mathematics knowledge and everyday knowledge is distinct or 'blurred' (the extent to which mathematic knowledge is related to everyday knowledge);
- the boundary between mathematics discourse and the discourse of other subjects is distinct or 'blurred' (the extent to which strong interdisciplinary relations are promoted through the use of themes);
- the teacher or learners *appear* to have control over micro selection (the degree to which learners have an influence over the selection activities, materials and contents within lessons);
- the teacher or learners *appear* to have control over micro sequencing (the degree to which learners have an influence over the ordering of activities, contents or use materials within lessons);

- the teacher or the learners *appear* to have control over micro pacing (the degree to which learners have an influence over the pacing of activities, materials and contents within lessons);
- the criteria for evaluation are implicit or explicit *a priori* [the degree to which the required mathematical procedures or principles underlying tasks or activities (recognition rules) are implicit *a priori*];
- the criteria for evaluating texts (realization rules) are implicit or explicit [the degree to which evaluation of learners' texts (products, answers, responses) focuses on what is present or valuable rather than on what is incorrect and 'missing'].

Four indicators were formulated to assess learners' exposure to pedagogical practices in relation to each of the thirteen elements (after Neves & Afonso, 2002). For example, the following are the indicators developed for measuring power relations between learners' spaces, that is, the degree to which classification of space in the classroom facilitates weakly or strongly framed social relationships between learners:

- Learners are always seated in a shared space. For example, learners are seated at desks or tables clustered together. (C--);
- Learners are mostly seated in a shared space but are sometimes seated in their own space (C-);
- Learners are mostly seated in their own space but are sometimes seated in a shared space. (C+);
- Learners are always seated in their own space. For example, learners are seated individually at desks in rows or in pairs at two-seater desks and have their own material. (C++).

Classroom observations were used to study teachers' pedagogical approaches. However, observations were not as intensively analysed as they are in smaller-scale studies such as those by Morais and Neves (2001); Neves and Afonso (2002); and Morais and Pires (2002). Rather, the intention was to collect relatively larger-grained data but in ways that made it possible to generalise across classrooms. A structured lesson observation schedule⁴⁴ (see Appendix 7) was designed so that each teacher's pedagogical approach could be

⁴⁴ The first section of the instrument was used to capture 'type of pedagogy' data. The second section was used to capture certain OTL data on cognitive demand, learner engagement, and exposure to word problems as described earlier in this chapter.

characterized in relation to each of the thirteen elements of classroom practice across a graded continuum. The following is the continuum for the degree to which communication relations between the teacher and learners are opened or closed:

Table 17: Continuum for the degree to which communication relations between the teacher and learners are opened or closed

Regulative context				
FRAMING CONTROL	ALWAYS F-- (4)	MOSTLY F- (3)	MOSTLY F+ (2)	ALWAYS F++ (1)
Hierarchical rules				
Degree to which communication relations between the teacher and learners are opened or closed				
12. COMMUNICATION RELATIONS BETWEEN THE TEACHER AND THE LEARNERS	Learners always appear to share control with the teacher over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	Learners mostly appear to share control with the teacher over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	The teacher mostly has explicit control over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	The teacher always has explicit control over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.

The two indicators for each element on the right represent 'teacher-centred' practices, that is, 'mostly' [F+/C+] or 'always' [F++/C++] strong values of framing or classification. The two indicators on the left represent learner-centred practices, that is, 'mostly' [F-/C-] or 'always' [F--/C--] weak values of framing or classification. In order to ensure that data collected was quantifiable, a 4-point scale was used to rate each indicator in terms of strong or weak classification or framing with a rating of 1 or 2 indicating strong classification or framing over power or control relations, in other words, a pedagogical practice centered on the teacher, and a rating of 3 or 4 indicating weak framing or classification over power or control relations, that is, a pedagogical practice centered on the learner. The idea behind the indicators was that pedagogical practices could be summarized in terms of a rating for each element of practice as well as a 'holistic' rating for all pedagogical elements combined.

As stated previously, because of the fairly large sample size, pedagogical practices were assessed with less fine-grained empirical detail than that of other Bernsteinian studies cited earlier. The four basic indicators formulated for each element on the observation schedule were designed to capture that which was dominant or sustained in each lesson observation for each of the thirteen elements of pedagogical practice. The intention was to characterize lessons in terms of their most 'general state' or the most 'common' or 'typical' practices in relation to each of the elements in terms of their indicators. Ratings were to be based on the

observer's general impression of how well the practices in the classroom matched the indicators for each element. Ratings for the thirteen elements were obtained by the rater's overall judgment of the proportion of the observation that a teacher devoted to a particular practice regardless of the duration of the observation.

Essential characteristics of teacher-centred/learner-centred practices were thus identified through fairly coarse-grained measures as it was deemed impractical to use a model that based ratings on indicators which capture classification or framing over micro components of different lessons in relation to each element as is done in more ethnographic case studies. Neither was it feasible to use a model that involved standardized counts for capturing frequencies of particular practices and dividing counts of the number of times the practices occurred by the length of the observation, because classes were observed for varying lengths of time. According to the timetables collected from each class teacher, class periods were typically 30-45 minutes long. However, as already explained in section 3.2.2 of this chapter, some of the mathematics lessons observed spanned a number of periods rather than just the allocated periods and it seemed inappropriate to limit the length of observations when trying to determine the pedagogical characteristics of lessons. For these reasons and reasons discussed in section 3.3.1, a 'trade-off' was made in terms of exactness and level of detail.

In case there was evidence of forms of practices not outlined in the indicators, the lesson observation instrument used made provision for brief field notes or comments on the elements of practice observed so that, if necessary, anomalous practices that fell beyond the 'idealised versions' outlined in the indicators could be captured. Chapter 6 explains how a more empirically-based analytical framework was developed for the analysis of 'type of pedagogy'.

The lesson observation instrument (see Appendix 10) was piloted in the fourth term of 2002 to test for variability prior to the study. Piloting took place in classes at schools that were representative of the socio-economic status of the sample but which were participating in an intervention that was promoting learner-centred approaches. In other words, it was piloted in contexts where variations in pedagogy were not 'naturally occurring' and where learner-centred approaches were likely to be evident.

3.3.1 Data collection

Learners' level of exposure to pedagogical practices was established in three lessons observations of each of the thirty eight classes participating in the study. One classroom observation of each of the 38 grade 6 maths classes took place in each of the first three terms of 2003.

I decided to distribute three observations over the three terms so that the data collected covered each teacher teaching a variety of topics over time. The idea was to use the observations spanning the three terms to try to establish the type of practices *typically* experienced by each learner within his/her mathematics class. The underlying assumption was that, even if a teacher does not consistently use a particular pedagogical practice but varies his or her use of pedagogical practices, teachers still tend to predominantly adopt either a more teacher-centred or a learner-centred form (Hallinan, 1989 in MacFarland, 2001: 640). Rowan, Correnti & Miller (2002: 26) recommend that, in a developed country context such as the USA, roughly 15-20 observations are needed to 'derive reliable measures of instructional processes', 'due to variation in daily instructional practice'. In the South African context we still have to identify the minimum number of observations required.

Data collection presented me with two further difficulties. The first was that across the three terms, data collection involved a total of one hundred and fourteen lesson observations in twenty four schools spread across four districts. I could not conduct this number of lesson observations effectively in the time available on my own, particularly as observations could not take place at the same time as the pre- and post-tests or when the collection of OTL data took place during the last two weeks of each term. Time available for observing lessons in the second term was further constrained in some schools in that grade 6 classes were occupied for 1-2 weeks in writing tests or assessment tasks and lesson observations could not take place during this time. In addition, my experience on other research projects had shown me that extra-curricular events at schools often also prevent lesson observations from taking place as planned. All of this could jeopardize the collection of three complete sets of classroom observation data on each class.

The second difficulty was that using the classroom observation schedule to rate pedagogical practices within lessons entailed the use of judgments requiring understanding and knowledge of mathematics and, to a lesser degree of the model's theoretical underpinnings.

The observation schedule was open to the extent that raters were required to exercise a degree of judgment in rating classroom practices. The principal challenge with regards to the instrument was in the interpretation of the indicators. Getting other people to video lessons for later review and rating of lessons would have been too costly and logistically difficult to organize. It could also be problematic if not all teachers were willing to have their lessons videotaped (see for example, Collins, 2001).

I estimated that I could observe at least a third of the lessons per term in the time available but realized that I would also need to engage and train three post-graduate mathematics students as raters or coders for lesson observations. Selection of these three raters was based on their background experience and qualifications as mathematics teachers, their competence in the two main languages of instruction at the schools (English and Afrikaans), and, at least an acquaintanceship with Bernstein's theory.

I trained the three coders to reach reasonably acceptable levels of rater agreement using a set of videotapes and lesson transcripts of grade 7 mathematics lessons in face-to-face training for one day prior to the beginning of the first term of 2003. 'Revision' sessions of training were held for half a day each prior to the second and third terms. As soon after each lesson observation as was convenient, raters emailed their ratings for each lesson observation and their reports consisting of field notes to me for review and comment. I used their field notes to check the ratings given and, if any inconsistencies in field notes and ratings were found, I immediately asked individual raters for clarification so that queries could be resolved or confirmed and a measure of inter-rater reliability maintained. This iterative process formed an important component of ongoing monitoring and regulation of data collection.

Because each of the raters had work obligations and engagements outside of the study, each of us made our own appointments for lesson observations at the schools so that data collection dates were spread across the 5-7 weeks available in each of the terms.⁴⁵ As far as was possible, each rater was allocated a different teacher each term so that each teacher's pedagogical practices were rated by different raters in each observation. The idea was to see if the ratings given by each of the observers were in effect validated by the ratings of the two

⁴⁵ This was also a limitation; because some teachers spent more than the allocated time on mathematics instruction, it was not always possible for an entire 'lesson' to be observed from start to finish as raters had to leave before the end was reached due to other work commitments.

other observers in their lesson observations. However, using different raters and comparing coding results as a test for reliability was not possible in two cases. One class comprised predominantly SeSotho speaking learners and the teacher said he often code switched between English, SeSotho and isiXhosa. Only one rater was competent in SeTswana which is similar to SeSotho. Because of the language constraint, this same rater had to observe and rate all three of this teacher's lessons. Another teacher was not amenable to being observed by more than one rater, so all his lessons were rated by the same observer. Nevertheless, in all other cases different observers were used and ratings for the various lessons were later compared (see Chapter 6 for further details).

The language of instruction used in all of the lessons was either Afrikaans or English. All four of us were competent in English and Afrikaans. In some classes isiXhosa is the primary language of most learners, and teachers code-switched and used English as well as isiXhosa in their lesson. Whenever such lessons were observed, a translator was employed to accompany raters and provide verbal translations of any isiXhosa classroom interactions that occurred during the lesson.

Teachers always received notice in advance that a rater was coming to observe a lesson as teachers indicated that it was not acceptable for us to simply show up for observations. During the lesson observations raters sat in a corner or at the back of the classroom and moved around the room only when learners were busy working on tasks so as to ensure that the observations were as unobtrusive as possible.

3.4. Individual learner background variables

An assumption in this study is that the sample of schools selected all serve learners with fairly homogenous socio-economic backgrounds. Low socio-economic status is inferred from a fairly narrow indirect measure of household income, namely school fees of less than R200. I felt that an effort needed to be made to measure and include data in the analysis on other individual learner level background variables (as distinct from the 'standardised' or 'community' proxy used for socio-economic status) such as education capital, social capital (Bourdieu, 1986; Coleman, 1988) and other factors associated with variations in learner achievement according to the international literature and more recent South African research.

A review of international literature and available evidence from South African research on the effects of background factors on learner achievement identified a number of learner characteristics or home background predictor variables for consideration. For example, although learner questionnaire data for South Africa were unavailable for the 1995 TIMSS, results for most TIMSS countries showed that the more books students reported in the home, the better their performance. 'Strong positive relationships were also found between achievement and having study aids such as a computer and a study desk/table for the student's own use' (Beaton, 1996). In a review of available evidence from South African research on the effects of background factors, Seekings (2001a) reported that a regression analysis done by Howie & Pietersen in South Africa of available data from the 1995 and 1999 TIMSS study for grade 12 indicated that learner achievement was 'markedly worse if the language of the test was not their first language.' Age was also a factor in that 'older students performed worse than younger ones' (Howie & Pietersen, nd in Seekings, 2001a: 109). In another South African study, Simkins (cited in Taylor *et al.*, 2003) similarly showed a strong association between grade 12 achievement and home language.

A South African study by Anderson *et al.* (2001 in Seekings, 2001a: 105) showed that 'family structure is correlated with schooling outcomes' where children who live with 'both genetic parents perform, on average, better than those living in any other domestic arrangement'. Studies by Anderson *et al.* (2001), Case & Deaton (1999) and Jubber (1998) all established 'a strong, positive relationship between mother's schooling and the schooling of their children' (Seekings, 2001a: 105). Simkins (cited in Taylor *et al.*, 2003: 54) found that settlement type 'had a marked effect on success rates' in the overall maths and science matric results in 1998 and 2000. Perry (2002 in Taylor *et al.*, 2003: 28-29) found that access to water was associated with learner achievement although 'the difference is not significant'.

Research in the United Kingdom and United States of America has for many years shown differences in girls and boys school achievement (Giddens, 2001: 516-517). For example, in the TIMSS, boys had significantly higher mean science achievement than girls at both the seventh and eighth grades in many countries (Beaton *et al.*, 1996). The second IEA science study conducted in 1983-84 similarly found that standard score differences for 14-year-olds favoured boys in participating countries (Postelthwaite & Wiley, 1992). Whilst gender has generally not been shown to have a strong association with school achievement in South

Africa (Taylor *et al.*, 2003: 54), Simkins (cited in Taylor *et al.*, 2003) used data from the 1998 October Household Survey and the 1996 Population Census to indicate that age, gender and settlement type jointly accounted for 30% of the variance in educational attainment.

Essentially the review of literature and research on the effects of background factors on learner achievement indicated the following variables:

- gender
- age
- family structure
- educational level of mother or main caregiver
- language use at home (as an operationalised proxy for race)
- settlement type or building
- basic cognitive resources at home
- mobility
- family expectations
- information channels – parent/child interaction
- norms, sanctions and network resources
- concurrent learning (extra mathematics lessons)

The categories of mobility, expectations or obligations, information channels – parent/child interaction - norms, sanctions and network resources all draw on the concept of social capital (Bourdieu, 1986; Coleman, 1988). The idea is that support from social networks and organizations such as churches, civic groups, etc. are powerful resources for individuals, families and communities (Dika & Singh, 2002). According to Coleman (1990: 318), ‘in a community where there is an extensive set of expectations and obligations connecting the adults, each adult can use his drawing account with other adults to help supervise and control his children.’ Putnam (1993: 35-36, 167) similarly argues that the most important forms of social capital are ‘features of social organizations, such as networks, norms and trust that facilitate action and cooperation for mutual benefit.’

Taylor *et al.* (2003: 55) summarise social capital as ‘a composite construct which comprises three forms: trust (expectations and obligations as measured by parental expectations),

information channels (as measured by parent-child and sibling interaction and inter-generational closure – meaning whether parents were friendly with their children’s friends), and norms and sanctions that promote the social good over self-interest.’ Parental participation and engagement in children’s schooling, for example, through attendance at school meetings, assistance with homework, and support through extra lessons, is considered to be associated with higher learner achievement (Floden, 2003). I thus decided to include information on aspects such as parental/caregiver attendance at school meetings and out-of-school or concurrent mathematics learning through extra lessons.

3.4.1 Data collection

A learner questionnaire was constructed to collect data on the categories of background measures outlined above (see Appendix 11). The intention was to use data from the learner questionnaires to examine differences in levels of achievement gain in relation to the various background variables associated with learner achievement identified in the international literature and recent South African research.

The proxy indicators used in the learner questionnaire for the study draw on relevant items from the student questionnaire used in the IEA’s TIMSS. However, the construction of questions also took into account modifications recommended by the US Department of Education’s National Centre for Education Statistics in a report on an investigation into ‘global usability problems’ of student questionnaire items (US Department of Education NCES, 2001: v). This investigation tested for error rates by comparing learner reporting with that of their parents. In this investigation questions were revised accordingly and the revised items re-tested to maximize reliability, although the study also found that ‘certain types of problems could not be corrected through minor item modifications’.

The questionnaire was translated from English into Afrikaans and isiXhosa and was administered to all learners in their home language after learners had completed the post-tests towards the end of the third term (except for the school where learners were predominantly SeSotho, where translation for only one class was simply too costly so the administrator had to translate whilst administering the tests). All administrators were instructed to read and explain each question to the whole class, telling learners what was required in the primary language of the majority of learners or in the language of instruction, whichever appeared to be more effective.

4. SUMMARY OF DATA SOURCES AND COLLECTION

In summary, data sources for the study are:

- 'grade 6' pre- and post-tests;
- grade 6 classroom observations of teachers' lessons and field notes or reports on lesson observations;
- the two most comprehensive of grade 5 and 6 learners' work books or files in each class;
- grade 5 and 6 teacher survey interviews;
- grade 5 and 6 teachers' year or term plans;
- reports by two grade 6 learners in each class on the daily content of instruction;
- grade 6 learner questionnaires.

The standardised pre- and post- tests were administered at the beginning and end of the academic school year. Learner questionnaires were administered together with the post-tests towards the end of the third term. Teacher survey interviews; examinations of teachers' year or term plans; the two most comprehensive of grade 5/6 learners' work books or files in each class; and reports by two grade 6 learners in each class on the daily content of instruction were carried as near as possible to the end of each term for the first three terms. Classroom observations took place during the first, second and third terms and were spread over the three terms (one per term for each class).

4.1 Reliability and validity issues

The following were strategies used to try to ensure reliability of data collection:

- piloting instruments beforehand (Mouton, 2001);
- training data collectors;
- gathering information over various points in time rather than once off (Rowan, 2002);
- not relying on self-report or survey approaches to data collection solely, but using more direct methods as well (McDonnell, 1995: 307);
- using standardised and structured data collection procedures and instruments wherever possible (Seliger & Shohamy, 1989);
- conducting quality control monitoring and moderating of data collection;
- triangulation using different sources (Seliger & Shohamy, 1989); and

- where instruments are less explicit and judgments are required – using different raters to observe, comparing coding from different raters (Babbie & Mouton, 2001), and checking field note data against the ratings awarded.

Strategies for addressing questions of internal and external validity were:

- trying to ensure homogeneity of SES amongst the sample in terms of SES (Seliger & Shohamy, 1989);
- using random sampling procedures (ibid);
- trying to ensure a large enough sample size and beginning with a larger than intended sample in case of attrition (ibid);
- taking into account extraneous variables, specifically difference in individual home background variables to check the degree to which individuals from the sample differed in other ways than that predicted by achievement (Rowan, 2002);
- using existing instruments, specifically the JET tests and items from the TIMSS student questionnaires that had been validated in other studies (Seliger & Shohamy, 1989; Mouton, 2001);
- drawing on a theoretical framework and methodological model for the classroom observation schedules that have been validated by other researchers (Seliger & Shohamy, 1989);
- using empirical measures of OTL that have face and construct validity (Babbie & Mouton, 2001);
- trying to take into account discrepant or inconsistent empirical data that could present a threat to theoretical validity (Maxwell, 1996).
- combining statistical evidence with a strongly elaborated conceptual framework and explicit concept variables (Taylor *et al.*, 2003).

However, as Babbie & Mouton (2001: 124) point out, a tension usually ‘exists between the criteria for reliability and validity’ necessitating ‘a trade-off between the two’.

Because

most of the really interesting concepts we want to study have many subtle nuances, and it’s hard to specify precisely what we mean by them ... Very often, then, the specification of reliable operational definitions and measurements seems to rob such concepts of their richness of meaning ... Yet,

the more variation and richness we allow for a concept, the more opportunity there is for disagreement on how it applies to a particular situation, thus reducing reliability. To some extent, this dilemma explains the persistence of two quite different approaches to social research... (ibid:125).

5. DATA ANALYSIS AND INTERPRETATION

First, descriptive statistics such as frequencies and central tendency are used to analyse and provide descriptive results for the four dimensions of the OTL construct, the thirteen elements of the 'type of pedagogy' construct, and the various individual learner background variables. Even if measures of each of the two focal constructs are not found to be significantly related to achievement in the statistical analysis, they are variables of interest in their 'own right' (Floden, 2003: 237).

Secondly, regression techniques are used to discover which of the various explanatory variables are significantly related to achievement gain, and to quantify their respective effects on achievement gain. 'Achievement gain' is measured as the difference between the pre- and post- tests and modeled as the response variable to the various explanatory variables.

The relative contributions of 'Opportunity-to-Learn' and 'type of pedagogy' variables on individual 'achievement gains' are examined as are other individual learner background variables to see if any particular variables affect the dependent or response variable more than any other. The objective of the regression analysis is to investigate the relationship between the various explanatory variables and the mathematics achievement gains of the random sample of 1001 low SES grade 6 learners in 38 classes in 24 schools from 4 Cape Peninsula districts. 'From multiple regression analysis we can obtain results showing which variables are significant in their contribution to explaining variance in the dependent variable *and* (their italics) how much variance they contribute' (Seliger & Shohamy, 1989: 226).

A series of regression models are fitted by firstly examining explanatory variables from each of the two constructs; then individual level learner background variables in isolation; and then attempting to combine them in one model. As the objective of the research is to investigate areas that education policy makers might profitably concentrate on, the analysis focuses on OTL and 'type of pedagogy'.

STATA was the program for conducting the regression analysis. The pre-test score was included in all the regression models in order to account for the starting level of the learners when assessing the effect of predictor variables on achievement gain. As discussed previously, including it in the models allows the impact of the other variables on achievement gain to be assessed after adjusting for the starting level of the learners.

Initially stepwise regression was used to assist in variable selection. This was specified with robust errors and with the schools in clusters in order to get more accurate estimates of the standard errors and account for the 'nested' nature of the OTL and 'type of pedagogy' data.. As elaborated in section 3.1 of this chapter, a feature of the methodology for this study is that, although the individual learner is the unit of analysis, learners within the same classes received the value for all of the 'type of pedagogy' and all (except one) of the OTL measures. Each of the models was then checked for validity by conducting diagnostics on the residuals and carrying out any necessary transformations.

Once a model was found to be valid it was re-specified using STATA's *svyreg* commands in order to include the fact that the districts were strata in the study design. The resulting coefficients and standard errors were then interpreted. Finally outliers and influential observations were examined.⁴⁶

The main objective was to carry out regression analysis using the individual learner as the unit of analysis so as to compare all the learners with each other. However, because hierarchical linear modeling (HLM), a multilevel statistical model, is often considered a more appropriate technique when data is of a 'nested' nature (such as learners nested within classes) (Bryk & Raubenbush, 1992, Lee, 1995; Rowan, 1995), a secondary analysis was carried out so as to compare the regression results using HLM to see whether the coefficients for significant variables change when individual and class level data are modeled at two separate levels (see Chapter 7). Briefly, the HLM focused on variation within and between classes by analysing data at the classroom level as well as individual learner level. The

⁴⁶ The following data manipulation was carried out. Firstly new variables indicating both district and school were generated from the original school codes. All binary variables were changed to be of the 0-1 form in order to ease interpretation by changing values of 2 to zeros. The demographic variables were imported into STATA as string variables and thus needed to be changed into numeric variables. Missing values were coded consistently across the dataset. Certain categorical variables from the learner questionnaire needed to be converted into a set of indicator variables (question 5 from the questionnaire). The variable *helphomework* (question 20 on the questionnaire) was recoded to improve on the ranked nature of the responses.

primary intention of the HLM was to compare the results of the regression modeling which overall allows more flexibility. HLM 5.4 was the software used to conduct this modeling.

The distribution of the mathematics achievement gain of the sample is provided in section 2.1 of Chapter 5 of the thesis together with an analysis of the relationships between the pre- and post-test score. A descriptive analysis of the sample of learners' OTL and a regression analysis of the relationship between measures of OTL and achievement are also provided in Chapter 5 of the thesis. A descriptive analysis of 'type of pedagogy' for the sample and statistical results of a regression analysis of the relationship between 'type of pedagogy' and the various elements of pedagogical practices and achievement gain are provided in Chapter 6.

Descriptive data on learner background variables is provided in Appendix 22. A regression analysis of the relationship between learners' individual background variables and achievement gain is provided in Chapter 7. Chapter 7 also provides results for the regression model combining all the OTL, 'type of pedagogy' and learner background variables that came out as significant for achievement gain in the three previous models. The chapter also provides a comparison of the results of regression modeling with the secondary analysis using HLM.

As a goal of the study is to make theoretical as well as empirical generalisations, the conceptual framework outlined in Chapter 3 is used as the basis of analysis (see Chapter 8).

6. RESUME OF THIS CHAPTER

The intention of the study is to conduct a medium-scale study of differences in learners' exposure to OTL and 'type of pedagogy' and to relate the relative effects of measures of the two constructs to measures of learners' mathematics achievement gains over one school year. In order to ensure a large enough sample size for the statistical analysis the unit of analysis in the study is the individual learner. Ultimately, the research analyses data from a random achieved sample of 1001 low SES grade 6 mathematics learners in 38 classes in 24 schools from four Cape Peninsula districts.

A relational research design is used to establish a) *naturally occurring* variations in the sample of learners' exposure to OTL and 'type of pedagogy' and b) whether there are

relationships between variations in measures of the two constructs and variations in measures of the mathematics achievement outcomes of the sample. As measures of prior achievement are likely to highly associated with prior exposure to the variables of interest in earlier grades and SES, learners' prior achievement was considered a key control variable for the dependent variable in the study. A further feature of the methodology used for assessing variation in learner's exposure to OTL and pedagogical type is that, with the exception of one individual level variable (the number of day's absent) learners in the same classes receive the same value for the 'type of pedagogy' and OTL measures.

The first requirement for measuring OTL was the construction of a Framework of Potential Curriculum Content to ensure that data collected across classes was comparable. Because of the idiosyncrasies of the version of C2005 in-use in 2003, the RNCS for the numeracy and mathematics Learning Area were used as the primary tool for constructing a framework. However, because many South African grade 6 learners are performing at lower levels than their grade requirements (Joint Education Trust, 2001; Seekings, 2001) and an assumption is that teachers are having to address gaps in learner knowledge and skills, the Framework includes curriculum content outlined for the Intermediate Phase as a whole (grade 4-6). The idea is to make it possible to portray within-grade content complexity and across-grade developmental complexity.

Table 18 summarises the target variables for the study, data sources, time of data collection and the instruments used in data gathering.

Table 18: Target variables, data sources, time of data collection and the instruments used in data gathering

	Variable/s	Measure/s	Data source/s	Time of data collection	Instruments
Achievement outcomes.	Gains in individual achievement.	Difference between pre- test and post-test score.	Pre- test measure of prior achievement and post-test measure.	At the beginning of the school year and at end of the third term.	116 of the 'Grade 6' mathematics tests items developed by the JET in consultation with the NDOH and the Institut voor Toetsontwikkeling.
OTL	Variable/s	Measure/s	Data source/s	Time of data collection	Instruments
Content coverage by cognitive demand (framing over macro pacing)	Grade 6 content coverage and emphasis.	Number of Intermediate Phase topics covered in grade 6.	Two most comprehensive of learners' workbooks or files in each class Structured teacher interview Teacher's year or term plans Two learner's reports on the daily content of instruction.	As close as possible to the end of each term for the first three terms.	Curriculum Coverage, Exposure, Coherence and Pacing Instrument; Grade 6 teacher interview schedule using the Framework of Potential Curriculum Content.
	Cognitive demand.	A rating based a point scale on a two dimensional rubric combining five content and five cognitive complexity levels.	Three lesson observations of each mathematics class.	Distributed over the first three terms of 2003 – one in each term.	Structured classroom observation schedule.
	Exposure to word problems.	Number of the three lessons in which engagement with word problems is observed.	Three lesson observations of each class.	Each of the first three terms.	Structured classroom observation schedule.
	Content exposure.	Number of pages of work in workbooks.	Two most comprehensive of learners' workbooks in each class.	As close as possible to the end of each term for the first three terms.	Grade 6 Curriculum Coverage, Exposure, Coherence and Pacing Instrument.
		Number of lesson observations where all learners appeared engaged in mathematics work.	Three lesson observations.	Distributed one in each of the first three terms.	Structured classroom observation schedule.
		Number of days each learner was marked as absent.	Class attendance registers.	As close as possible to the end of each term for the first three terms.	Grade 6 Curriculum Coverage, Exposure, Coherence and Pacing Instrument (using class lists).

Table 18 cont.

OFL	Variable/s	Measure/s	Data sources	Time of data collection	Instrument/s
Curricular coherence (framing over macro sequencing)	Sequence and spread of topics.	A combined rating based on a point scale on a two dimensional rubric of three sequence and spread levels	Two most comprehensive of learners' workbooks or files in each class Structured teacher interview Teacher's year or term plans Two learner's reports on the daily content of instruction. Curriculum expert judges developmental complexity against a topic sequence and spread matrix.	As close as possible to the end of the first three term After the third term 2003.	Grade 6 Curriculum Coverage, Exposure, Coherence and Pacing Instrument - mapping the order in which topics/sub-topics are covered across three terms. Two dimensional rubric of sequence and spread with a 3-point scale.
Curricular pacing (framing over macro pacing)	Pacing across two adjacent grades (Grade 5 & 6 content coverage and emphasis).	Number of Grade 5 topics covered in Grade 5. Number of topics covered in Grade 6.	Two most comprehensive of learners' workbooks or files in each class Structured teacher interview Teacher's year or term plans. See Grade 6 content coverage and emphasis above.	As close as possible to the end of each term for the first three terms. See Grade 6 content coverage and emphasis above.	Grade 5 Curriculum Pacing Instrument Grade 5 teacher interview schedule using the Framework of Potential Curriculum Content. See Grade 6 content coverage and emphasis above.
'Type of pedagogy'	Thirteen key variables generated primarily from Bernstein's conceptual framework - 47 elements for the instructional and 6 element for the regulative context) for characterising the 'type of pedagogy' through the use of four indicators.	Elements of pedagogy rated in terms of strong or weak classification or framing, and ratings for all elements combined for an overall rating for teacher/learner-centered pedagogy; teacher-learner and learner-learner spaces; teacher-learner and learner-learner hierarchical relations; teacher-learner and learner-learner communication relations; relations between maths and everyday discourse; and maths and the discourse of other subjects; micro selection, sequencing, pacing; and evaluation criteria.	Three lesson observations of each class.	Distributed over three terms - one per term.	Structured lesson observation schedule that makes provision for brief field notes on each of the variables.

Table 18 cont.

OTL	Variable/s	Measure/s	Data source/s	Time of data collection	Instrument/s
Home background.	Individual level background variables.	Age, gender, family structure, educational level of mother/ main caregiver, language use at home, settlement type, building, basic cognitive resources at home, mobility, family expectations, information channels, parent/child interaction, norms, sanctions and network resources, concurrent learning.	Learner completed questionnaires.	After learners complete the post-tests towards the end of the third term.	A learner questionnaire which draws on relevant items from the questionnaire used in the IEA's TIMSS.

Regression techniques are used to discover which of the possible explanatory variables are significantly related to achievement gain, and to quantify their respective effects on achievement gain. A series of regression models are fitted firstly by examining explanatory variables from 'opportunity-to-learn', 'type of pedagogy', and the individual level learner background variables and other demographic variables in isolation, and then by attempting to combine all the significant variables from the three previous models in one model. The results of a secondary analysis using HLM are compared to the results of the regression modeling to see if the actual coefficients for the significant variables change much when individual level data is modeled within class and class-level data is modeled between-classes.

The next three chapters (5, 6 and 7) provide the descriptive and statistical analysis of the relationship between the variables of interest and achievement outcomes for the sample. The primary objective of the analysis is to establish which of the focal constructs contributes the most to increases or decreases in achievement growth of low SES learners in a South African context. Chapter 8 relates the findings to the analytical model and the research hypothesis.

Group 1		Group 2		Group 3		Group 4	
Year	Age	Year	Age	Year	Age	Year	Age
1990	10	1991	11	1992	12	1993	13
1994	14	1995	15	1996	16	1997	17
1998	18	1999	19	2000	20	2001	21
2002	22	2003	23	2004	24	2005	25
2006	26	2007	27	2008	28	2009	29
2010	30	2011	31	2012	32	2013	33
2014	34	2015	35	2016	36	2017	37
2018	38	2019	39	2020	40	2021	41
2022	42	2023	43	2024	44	2025	45
2026	46	2027	47	2028	48	2029	49
2030	50	2031	51	2032	52	2033	53
2034	54	2035	55	2036	56	2037	57
2038	58	2039	59	2040	60	2041	61
2042	62	2043	63	2044	64	2045	65
2046	66	2047	67	2048	68	2049	69
2050	70	2051	71	2052	72	2053	73
2054	74	2055	75	2056	76	2057	77
2058	78	2059	79	2060	80	2061	81
2062	82	2063	83	2064	84	2065	85
2066	86	2067	87	2068	88	2069	89
2070	90	2071	91	2072	92	2073	93
2074	94	2075	95	2076	96	2077	97
2078	98	2079	99	2080	100	2081	101
2082	102	2083	103	2084	104	2085	105
2086	106	2087	107	2088	108	2089	109
2090	110	2091	111	2092	112	2093	113
2094	114	2095	115	2096	116	2097	117
2098	118	2099	119	2100	120	2101	121
2102	122	2103	123	2104	124	2105	125
2106	126	2107	127	2108	128	2109	129
2110	130	2111	131	2112	132	2113	133
2114	134	2115	135	2116	136	2117	137
2118	138	2119	139	2120	140	2121	141
2122	142	2123	143	2124	144	2125	145
2126	146	2127	147	2128	148	2129	149
2130	150	2131	151	2132	152	2133	153
2134	154	2135	155	2136	156	2137	157
2138	158	2139	159	2140	160	2141	161
2142	162	2143	163	2144	164	2145	165
2146	166	2147	167	2148	168	2149	169
2150	170	2151	171	2152	172	2153	173
2154	174	2155	175	2156	176	2157	177
2158	178	2159	179	2160	180	2161	181
2162	182	2163	183	2164	184	2165	185
2166	186	2167	187	2168	188	2169	189
2170	190	2171	191	2172	192	2173	193
2174	194	2175	195	2176	196	2177	197
2178	198	2179	199	2180	200	2181	201
2182	202	2183	203	2184	204	2185	205
2186	206	2187	207	2188	208	2189	209
2190	210	2191	211	2192	212	2193	213
2194	214	2195	215	2196	216	2197	217
2198	218	2199	219	2200	220	2201	221
2202	222	2203	223	2204	224	2205	225
2206	226	2207	227	2208	228	2209	229
2210	230	2211	231	2212	232	2213	233
2214	234	2215	235	2216	236	2217	237
2218	238	2219	239	2220	240	2221	241
2222	242	2223	243	2224	244	2225	245
2226	246	2227	247	2228	248	2229	249
2230	250	2231	251	2232	252	2233	253
2234	254	2235	255	2236	256	2237	257
2238	258	2239	259	2240	260	2241	261
2242	262	2243	263	2244	264	2245	265
2246	266	2247	267	2248	268	2249	269
2250	270	2251	271	2252	272	2253	273
2254	274	2255	275	2256	276	2257	277
2258	278	2259	279	2260	280	2261	281
2262	282	2263	283	2264	284	2265	285
2266	286	2267	287	2268	288	2269	289
2270	290	2271	291	2272	292	2273	293
2274	294	2275	295	2276	296	2277	297
2278	298	2279	299	2280	300	2281	301
2282	302	2283	303	2284	304	2285	305
2286	306	2287	307	2288	308	2289	309
2290	310	2291	311	2292	312	2293	313
2294	314	2295	315	2296	316	2297	317
2298	318	2299	319	2300	320	2301	321
2302	322	2303	323	2304	324	2305	325
2306	326	2307	327	2308	328	2309	329
2310	330	2311	331	2312	332	2313	333
2314	334	2315	335	2316	336	2317	337
2318	338	2319	339	2320	340	2321	341
2322	342	2323	343	2324	344	2325	345
2326	346	2327	347	2328	348	2329	349
2330	350	2331	351	2332	352	2333	353
2334	354	2335	355	2336	356	2337	357
2338	358	2339	359	2340	360	2341	361
2342	362	2343	363	2344	364	2345	365
2346	366	2347	367	2348	368	2349	369
2350	370	2351	371	2352	372	2353	373
2354	374	2355	375	2356	376	2357	377
2358	378	2359	379	2360	380	2361	381
2362	382	2363	383	2364	384	2365	385
2366	386	2367	387	2368	388	2369	389
2370	390	2371	391	2372	392	2373	393
2374	394	2375	395	2376	396	2377	397
2378	398	2379	399	2380	400	2381	401
2382	402	2383	403	2384	404	2385	405
2386	406	2387	407	2388	408	2389	409
2390	410	2391	411	2392	412	2393	413
2394	414	2395	415	2396	416	2397	417
2398	418	2399	419	2400	420	2401	421
2402	422	2403	423	2404	424	2405	425
2406	426	2407	427	2408	428	2409	429
2410	430	2411	431	2412	432	2413	433
2414	434	2415	435	2416	436	2417	437
2418	438	2419	439	2420	440	2421	441
2422	442	2423	443	2424	444	2425	445
2426	446	2427	447	2428	448	2429	449
2430	450	2431	451	2432	452	2433	453
2434	454	2435	455	2436	456	2437	457
2438	458	2439	459	2440	460	2441	461
2442	462	2443	463	2444	464	2445	465
2446	466	2447	467	2448	468	2449	469
2450	470	2451	471	2452	472	2453	473
2454	474	2455	475	2456	476	2457	477
2458	478	2459	479	2460	480	2461	481
2462	482	2463	483	2464	484	2465	485
2466	486	2467	487	2468	488	2469	489
2470	490	2471	491	2472	492	2473	493
2474	494	2475	495	2476	496	2477	497
2478	498	2479	499	2480	500	2481	501
2482	502	2483	503	2484	504	2485	505
2486	506	2487	507	2488	508	2489	509
2490	510	2491	511	2492	512	2493	513
2494	514	2495	515	2496	516	2497	517
2498	518	2499	519	2500	520	2501	521
2502	522	2503	523	2504	524	2505	525
2506	526	2507	527	2508	528	2509	529
2510	530	2511	531	2512	532	2513	533
2514	534	2515	535	2516	536	2517	537
2518	538	2519	539	2520	540	2521	541
2522	542	2523	543	2524	544	2525	545
2526	546	2527	547	2528	548	2529	549
2530	550	2531	551	2532	552	2533	553
2534	554	2535	555	2536	556	2537	557
2538	558	2539	559	2540	560	2541	561
2542	562	2543	563	2544	564	2545	565
2546	566	2547	567	2548	568	2549	569
2550	570	2551	571	2552	572	2553	573
2554	574	2555	575	2556	576	2557	577
2558	578	2559	579	2560	580	2561	581
2562	582	2563	583	2564	584	2565	585
2566	586	2567	587	2568	588	2569	589
2570	590	2571	591	2572	592	2573	593
2574	594	2575	595	2576	596	2577	597
2578	598	2579	599	2580	600	2581	601
2582	602	2583	603	2584	604	2585	605
2586	606	2587	607	2588	608	2589	609
2590	610	2591	611	2592	612	2593	613
2594	614	2595	615	2596	616	2597	617
2598	618	2599	619	2600	620	2601	621
2602	622	2603	623	2604	624	2605	625
2606	626	2607	627	2608	628	2609	629
2610	630	2611	631	2612	632	2613	633
2614	634	2615	635	2616	636	2617	637
2618	638	2619	639	2620	640	2621	641
2622	642	2623	643	2624	644	2625	645
2626	646	2627	647	2628	648	2629	649
2630	650	2631	651	2632	652	2633	653
2634	654	2635	655	2636	656	2637	657
2638	658	2639	659	2640	660	2641	661
2642	662	2643	663	2644	664	2645	665
2646	666	2647	667	2648	668	2649	669
2650	670	2651					

Chapter 5

DATA ANALYSIS: 'OPPORTUNITY-TO-LEARN'

As previously stated, the intention of this study is to identify the relative effects on the mathematics achievement gain of measures of two focus constructs, 'Opportunity-to-Learn' and 'type of pedagogy' whilst controlling for the SES of a sample of grade 6 learners from four Cape Peninsula districts.

The first section of Chapter 5 provides descriptive results for the four key dimensions of the OTL construct – 'content coverage by cognitive demand', 'content exposure', 'curricular coherence', and 'curricular pacing'. The second section presents results from the first of a series of four regression models, modeling predictor variables of 'Opportunity-to-Learn' to discover which, if any, of the OTL measures are significantly related to achievement gain. However, in response to the findings on OTL presented in section 1 and 2, I decided to explore the relationship between the pre-test and post-test scores and curricular pacing to check whether measures of OTL might be more important in relation to overall achievement status than to gain over one school year. The third section of the chapter outlines results of this exploration.

1. DESCRIPTIVE ANALYSIS: 'OPPORTUNITY-TO-LEARN'

1.1 Content coverage by cognitive demand

Section 1.1 provides a descriptive analysis of

- 'content coverage and emphasis', the mathematics topics and sub-topics actually taught during the course of the school year and the emphasis given to or amount of time spent on the various contents (for example, variations in how many lesson periods devoted to particular topics or sub-topics);
- 'content by cognitive demand'; and
- 'exposure to word problems'

Content coverage and emphasis

When data collection on content coverage and emphasis for all three terms for each grade 6 class at each school had been completed, information from the three terms for each class was

captured onto a single copy of the Grade 6 Mathematics Curriculum Coverage, Exposure, Coherence and Pacing Instrument. The Framework of Potential Curriculum Content on the Instrument comprising curriculum content outlined in the RNCS for the Intermediate Phase as a whole (grade 4-6) was used to obtain a detailed description of the content made available to each of the grade 6 learners in the first three terms of 2003 in terms of content complexity and emphasis.

With these data, it was possible to compare the Intermediate Phase mathematics content on the Framework with what was actually made available to learners. I was able to calculate the percentage of the 1001 grade 6 learners who had covered each of the Intermediate Phase sub-topics on the Framework at specific grade levels as follows:

Content levels	Percentage of learners who covered
Grade 4, 5 or 6	0-100%

The data also allowed me to estimate the percentage of grade 6 learners who were taught the minimum content considered necessary for grade 6. I was able to calculate the estimated average number of lessons actually spent on the various sub-topics where they were covered and to compare the emphasis given to grade 6 level sub-topics with the estimated ideal number of lessons on the Framework.

For example, the following is an extract of aggregated results for grade 6. The content outlined in the Framework is presented to assist the reader in interpreting the information. Grade 6 sub-topics covered by half (50%) or more of the grade 6 learners are shaded. In other words, shading indicates that at least 50% of grade 6 learners had an opportunity to learn that particular grade 6 content. The numbered boxes of sub-topics which are related to the grade 6 expectations are also shaded. If grade 6 content is not shaded, this indicates that less than 50% of the sample of learners had an opportunity to learn that particular content. 'X' indicates that less than one lesson was spent on a sub-topic.

Figure 3 : Extract of aggregated results for grade 6 content coverage and emphasis

SECTION 1: NUMBER, OPERATION AND RELATIONSHIPS:					
1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS		% of learners that covered	Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
			Number of single 20 min periods	Less than one	If one or more, estimated average no. single periods
Counting including:					
Counting forwards and backwards in					
1	• 2s			X	
2	• 3s			X	
3	• 5s			X	
4	• 10s				1
5	• 25s				1
6	• 50s				1
7	• 100s				1
8	• a variety of whole number intervals between 0 and 10 000 (e.g. 1000-2000)				1
9	• fractions (e5)	45			2
	• decimals (e6)	26	2-4		2
Representing and comparing whole numbers including zero and fractions including:					
Whole numbers to					
11	• 4-digit numbers (e5)				3
12	• 6-digit numbers (e6)				3
	• 9-digit numbers (e6)	21	4-6	X	

The above data indicate that at least 50% of the grade 6 learners covered 'Counting forwards and backwards in 2s, 3s, 5s, 10s, 25s, 50s, 100s and a variety of whole number intervals between 0 and 10 000 which relate to grade 4 and 5 expectations. Greater emphasis (1 period) was placed on counting in 10s, 25s, 50s, 100s and a variety of whole number intervals between 0 and 10 000 than was placed on counting in 2s, 3s, 5s (less than 1 period). Only 26% of the learners were exposed to 'counting forwards and backwards in decimals' which relates to grade 6 level expectations. Over 50% of the learners were exposed to representing and comparing 4-6- digit whole numbers (an estimated 3 periods on each) which relates to grade 4 and 5 level expectation as opposed to only 21% of the learners who were exposed to 9-digit whole numbers at the expected grade 6 level for on average less than 1 period as compared to the notional ideal of 4-6 periods. (see Appendix 12 for more comprehensive details)

The data reveals the following patterns of ‘content coverage’ for the 1001 grade 6 learners. By mid – September 2003 (the end of the third quarter)

- on average grade 6 learners covered 29% of *all* the Intermediate Phase (IP) sub-topics on the Framework of Potential Curriculum Content but the percentage of IP sub-topics covered in grade 6 ranged from 12% to 70%.
- the average coverage of sub-topics considered essential for the grade 6 level in grade 6 was 22% of those on the Framework of Potential Curriculum Content but the percentage of grade 6 level topics covered ranged from 5% to 55%.

The grade 6 content coverage and emphasis data reveal that there are enough commonalities in terms of the outcomes emphasized and the sub-topics covered across grade 6 to indicate the curriculum generally made available to the 1001 learners in grade 6 (see Appendix 13).

To recap: Data reveal evidence of low content coverage (slow across grade pacing) in terms of the number of topics covered in grade 6. They also show that the sample of grade 6 learners spent more time on sub-topics they were expected to have covered in grade 4 and 5 than they did on sub-topics at the level expected for grade 6.

Content by cognitive demand

The five content and cognitive complexity levels provided in Chapter 4 were used to analyse variations in learners’ cognitive levels of engagement with mathematics content in the lesson observations. Interestingly, data show that the content level in 60% of the 114 *lessons observed* was mostly at the level considered essential for grade 6. This could indicate ‘researcher effects’ in that teachers may have decided to focus on grade 6 content when they were observed (Seliger & Shohamy, 1989: 109). The content level was mostly below that expected for grade 6 in 36% of all the lessons observed (in 8% of these lessons the content was mostly at Foundation Phase level). In 4% of the lessons the content level was higher than that expected for the Intermediate Phase.

However, the cognitive level at which learners were engaged with the content in 22% of the lessons was deemed to be low, for example, learners were mainly engaged in tasks such as drawing, colouring, or at conceptual levels that did not progress to engagement with

specialized mathematical procedures or principles. An illustrative indication of this category from field notes of a lesson observation is provided in Appendix 14.

In 41% of the lessons learners were engaged in routine mathematics procedures, which did not progress to engagement with underlying knowledge principles. In 30% of the lessons, learner engagement was mostly at procedural levels with evidence of some engagement with underlying mathematical principles. As this is the category which was most prevalent, it is exemplified in the following illustrative extract of ‘engagement mostly at procedural levels’ from field notes. It is important to note that the field notes are not ‘raw data’ but consist of the rater’s reconstructions or interpretations of the observations.

Illustrative extract from field notes of ‘engagement mostly at procedural levels’.

The lesson focused on distinguishing between those numbers that are divisible by 2 and those that are divisible by 3. The teacher provided procedures for determining divisibility on the chalkboard. By the time learners began the seatwork tasks, they knew that by adding the digits of a number, they could determine whether it was divisible by 3 if the sum of its digits was either 3, 6 or 9. If the sum yielded a number of 2 or more digits, they could continue the summation process until they got a single digit of either 3, 6 or 9 (for divisibility by 3). The procedure for determining divisibility by 2 was similarly made explicit, for example, ‘see whether the (whole) number ends with a 2, 4, 6, 8 or 0’. The exercise that the teacher gave learners to do was on a photocopied page which also offered an explanation about divisibility of numbers other than 2 and 3. This was the only explicit form of generalisation that learners were exposed to with regard to divisibility but the teacher did not directly refer learners to this text in the lesson.

In just 7% of the lessons observed learners were apparently engaged to a greater extent with mathematics knowledge principles. An illustrative indication of this category of learner engagement from field notes of a lesson observation is provided in Appendix 14.

To recap: Data indicate that 71% of the learners were engaged with mathematics content at procedural levels with, at most, a low degree of engagement with mathematics knowledge principles. One third of the learners were engaged either with content that was below the grade 6 level or at very low cognitive levels that did not progress to engagement with any form of specialized mathematics knowledge.

Exposure to word problems

The other component of the 'content coverage by cognitive demand' variable included in the study is learners' levels of exposure to word-problems. None of the learners appeared to have high levels of exposure to word problems in the lesson observations. 34% of the learners apparently had no exposure to word problems in any of the three lessons observations. 42% of the learners experienced low levels of exposure to word problems in the lessons observed. There was evidence of higher levels of exposure to word problems for the remaining 24% of the learners.

To recap: Data indicated that 76% of the learners had no or low levels of exposure to word problems.

1.2. Content exposure

The next section provides a descriptive analysis of 'content exposure' – measures of the absolute amount of time actually spent engaged with mathematics content as opposed to the amount of time allocated for mathematics instruction. This 'time on task' and 'academically engaged time' variable was measured in terms of a) the number of pages of work in the two most comprehensive of learner's workbooks in each class by the end of the third term, b) the extent to which all learners in each class were equally engaged with mathematics in the three observed lessons, and c) the number of days each learner was absent as reflected in class attendance registers.

58% of the grade 6 learners appeared to be equally engaged in the assigned mathematics work in all three lesson observations. 24% of the learners appeared to be equally engaged in two of the three lessons observed. 8% of the learners appeared to engage equally in mathematics work in just one of the three lessons observed. 11% of the learners were not equally engaged in mathematics work all three lesson observations.

Available data indicated that the average number of days learners were absent was 8 days (median of 5 and a mode of 0). The number of days absent ranged from 0 to 66 days with a Standard Deviation (SD) of 8.3 indicating that most learners had fairly low levels of absenteeism.

The other 'content exposure' data showed that by the end of the third term, the sample of grade 6 learners had on average 121 pages of work in their maths notebooks (median of 125 and a mode of 119). The number of pages of work in mathematics notebooks ranged from 49 to 214 with a moderate SD of 41.

To recap: For 58% of the learners, engagement of the entire class in mathematics work was evident across all three lessons observations. In 42% of the cases, some learners were noticeably off task in at least one of the three lesson observations. On average, by the end of the third term, learners had 121 pages of work in their maths notebooks. The average number of days learners were absent was 8 days. With a few exceptional cases, measures of central tendency show that content exposure measured as the number of days absent and the number of pages of work in notebooks was not that variable for most of the sample.

1.3. Curricular coherence

The following section provides descriptive data on 'curricular coherence' which is the extent to which grade 6 mathematics content and topics are presented in a logical and sequential order across the academic school year in terms of developmental complexity.

Curricular spread in 50% of the cases showed good spread of outcomes across the three terms. Curricular spread in 24% of the grade 6 cases was deemed to show poor spread of outcomes across the three terms. Curricular spread in 26% of the cases showed some spread of outcomes across the three terms.

Curricular sequencing in only 8% of the cases reflected good sequential development of mathematics concepts or procedures with isolated exceptions. Curricular sequencing in 76% of the cases mostly did not reflect sequential development of mathematics concepts or procedures. The remaining 16% of the cases fell in-between these two categories – and reflected some sequential development.

To recap: Whilst the spread of outcomes across the three terms was generally good, curricular sequencing across the three terms for 76% of the learners was deemed very poor in that the order in which topics were covered mostly did not reflect internal disciplinary principles through sequential development of mathematics concepts or procedures.

1.4. Curricular pacing

The section that follows provides descriptive results for 'curricular pacing' - measures of each school's structuring or pacing of curriculum across adjacent grades or across grade developmental complexity. In the study pacing across the Intermediate Phase grade adjacent to grade 6, namely, grade 5, was measured to determine whether learners experienced conceptual advancement in mathematics content across grades.

Data on mathematics 'content coverage' and 'content emphasis' (the number of lessons spent on each of the topics or sub-topics) for grade 5 were collected at each school through the use of the Survey of Curriculum Content Emphasis Instrument developed for grade 5. Data collected in 2003 on content coverage and emphasis in grade 5 mathematics classes at each school were used to infer the grade 5 mathematics content that each of the 1001 grade 6 learners had covered the previous year. This allowed me to calculate the percentage of the sample of grade 6 learners exposed to each of grade 5 sub-topics in their first three terms in grade 5. I was also able to calculate the estimated average number of lessons actually spent on the various sub-topics where they were covered and to compare this with the estimated ideal number of lessons for grade 5 sub-topics on the Framework.

In the following extract from the grade 5 analysis, grade 5 sub-topics covered by at least 50% of the sample are shaded. In other words, shading indicates evidence that in at least 50% of the grade 6 learners had an opportunity to learn that particular grade 5 content. If grade 5 content (see boxes in the first column) is not shaded, this indicates evidence that less than 50% of the sample had had opportunities to learn that particular content in grade 5. 'X' indicates that less than one lesson was spent on a sub-topic.

Figure 4 : Extract of aggregated results from grade 5 content coverage and emphasis

SECTION 2: MEASUREMENT:					
			% of classes that covered	Estimated average number of lessons spent on content	
				Less than one	If one or more, estimated average no. single periods
	2.1 TIME				Ideal – number single 50 min periods
	Reading and writing analogue, digital and 24-hour time including:				
	Analogue time (time read from a clock with a face and hands)				
	• to the nearest minute (g4,5,6)		67		2
	• to the nearest second (g4,5,6)		67		2
	Digital time (time read from a clock that has a continually changing digit display rather than a clock face)				
	• to the nearest minute (g4,5,6)		33		1
	• to the nearest second (g4,5,6)		21		1
	24-hour time				
	• to the nearest minute (g4,5,6)		29		1-2
	• to the nearest second (g4,5,6)		28		1-2
	Solving problems involving calculation and conversions between appropriate time units including:				
98	• minutes (g4)				1
99	• minutes (g5)				1
100	• hours (g4)				1
101	• days (g4)				1
102	• weeks (g4)				1
103	• months (g5)				1
104	• years (g4)		42		1
	• decades (g5)		40	X	1
	• centuries (g5)		0		1
	• millennia (g5)		0		1
108	• time zones and differences (g6)		0		0

The above data show that in grade 5 learners are generally covering solving problems involving calculations and conversions between time units at grade 4 level expectations (numbers 98-103) and that an estimated average of 6 periods was spent on this overall. Little or no attention was paid to grade 5 level expectations (numbers 105-107). 40% of the sample spent an estimated average of less than one period on ‘decades’ and none of the learners appeared to cover ‘centuries’ or ‘millennia’. Data showed that on average 31% of all the IP sub-topics on the Framework were covered in grade 5 but the percentage covered ranged from 5% to 67% (for complete details see Appendix 12).

Data on grade 5 content coverage and emphasis reveal evidence of enough commonalities in terms of the outcomes emphasized and the sub-topics covered to indicate the curriculum generally made available to the 1001 learners in grade 5 (see Appendix 13).

An analysis of 'content coverage and emphasis' in grade 5 and 6 reveals the following interesting patterns of curricular pacing for the sample of 1001 learners. Data indicate that by the end of the third quarter

- in both grade 5 and 6, curricular attention was strongest for two of the five RNCS outcomes, namely Learning Outcome (LO) 1: Number, Operations and Relationships; and LO4: Measurement. The mathematics curriculum made available to the sample of learners in grade 5 and 6 was primarily one of Number and Measurement.
- In grade 5 no one sub-topic in three Learning Outcomes, namely LO 2: Patterns, Functions and Algebra, LO 3: Space and Shape (Geometry) or LO 5: Data Handling was covered by 50% or more of the 1001 learners. In grade 6, only one sub-topic of LO 2: Patterns, Functions and Algebra and LO 5: Data Handling on the Framework was covered by 50% or more of the classes. None of the sub-topics in LO 3: Space and Shape (Geometry) on the Framework was covered by 50% or more of the grade 6 learners. This indicates that there is wide variability amongst the sample in terms of the sub-topics covered or not covered for these three outcomes in both grade 5 and 6.
- Only 19% of the sub-topics on the Framework of Potential Curriculum Content considered essential at the grade 5 level were covered by 50% or more of the learners in grade 5. Only 20% of the sub-topics on the Framework considered essential at the grade 6 level were covered by 50% or more of the learners in grade 6.
- Data on grade 5 content coverage indicate that the average coverage of all the sub-topics considered essential at the grade 5 level was 29%. However, the percentage of the grade 5 sub-topics covered in grade 5 ranged from 4% to 70%.
- 71% of the sub-topics covered by 50% or more of the learners in grade 6 were also covered in at least 50% of the classes in grade 5. Evidently only 29% of the sub-topics covered by 50% or more of the learners in grade 6 were introduced for the first time in grade 6.

To recap: Although the common emphasis on Number and Measurement evident at the grade 5 and 6 level is in line with the very broad guidelines for allocating time for each of the five mathematics outcomes in the Intermediate Phase originally suggested in Draft number 2 of the MLPPG (NDoE, nd) overall curricular attention for the other three LOs in both grades appears to be much weaker. Certainly levels of sub-topics for the three outcomes covered by 50% or more of the learners are extremely low.

Descriptive data show that learners are spending more time on sub-topics that they were expected to have covered in earlier grades than they do on sub-topics at the level expected for their grade. Data reveal evidence of slow curricular pacing across grades 5 and 6. Poor pacing across grades appears to be leaving learners 'farther and farther behind' (Smith, Smith & Bryk, 1998: 2). Descriptive data also suggest that similar content and concepts are being taught 'again and again' and that the 'classroom life' of learners consists 'of repetitive cycles of basic skills instruction' (ibid: 22) as well as 'gaps in instruction' (ibid: 26). Indications are that learners are experiencing 'delays, repetitions, and/or skips in core knowledge and skills in ways that seriously diminish their chances for success in school and, in particular, on tests used to measure their knowledge and their progress' (ibid: 29).

Section 2 of this chapter presents the statistical analysis of the influence on OTL on learners' mathematics achievement.

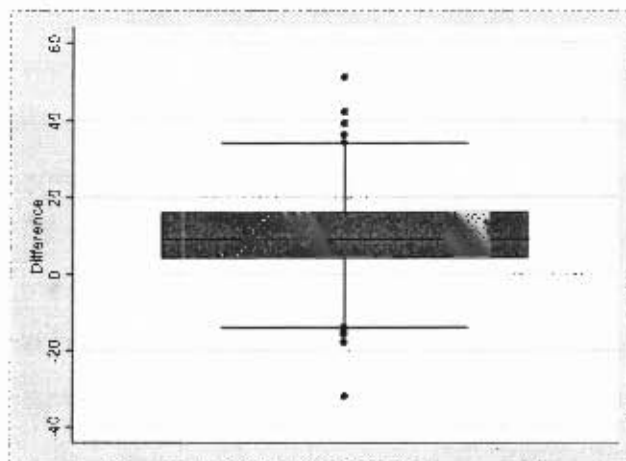
2. STATISTICAL ANALYSIS: 'OPPORTUNITY-TO LEARN'

The overall objective of the statistical analysis is to investigate the relationship between the mathematics gains of the 1001 low SES grade 6 learners and the explanatory variables. However, before any models were built, the distribution of the mathematics gain scores of the learners was explored.

2.1 Distribution of gain scores

When the distribution of the mathematics achievement gain of the 1 001 learners measured as the difference between the pre- and post test scores was explored, the boxplot (figure 5) below shows the distribution of gain to be fairly symmetrical, approximately normal with some extreme values on the both the lower and upper end.

Figure 5: Achievement gains boxplot (pre- and post- test difference)



Although the spread of the box or middle 50% of the data is relatively narrow and ranges from 4 to 16, considerable variation in achievement gain is observed. The range of between -32 and 51 represents extremes in both lower and higher gain whilst the overall mean gain for the sample was 9.96.

Table 19 below summarises the distribution of achievement gains:

Table 19: Summary statistics of achievement gain

<i>N</i>	<i>Mean gain</i>	<i>Median</i>	<i>Mode</i>	<i>SD</i>	<i>Min gain</i>	<i>Max gain</i>
1001	9.96	9	5	9.26	-32	51

N= Number of learners in the sample

The standard deviation shows that approximately 95% of the data lies within ± 2 standard deviations from the mean, that is, from about -8.5 to 28.5.

2.2 Modeling ‘Opportunity to Learn’

This section provides the results for modeling predictor variables of ‘Opportunity-to-Learn’ to discover which if any of the OTL measures are significantly related to achievement gain.

2.2.1 Data exploration

To identify the OTL variables to become part of the first regression model, a correlation matrix of the various independent variables and achievement gain was first generated. The correlation matrix was used to identify linear associations between each of the *continuous* independent variables and the dependent variable.

The variables that had the highest correlation with achievement gain were levels of *cognitive demand* (a correlation co-efficient of 0.28) and learners' *absentee* rate (number of days recorded as absent in the attendance register) (a correlation co-efficient of -0.12). However, it was also evident that some of the OTL variables were highly correlated with each other. Measures that were very highly correlated included *grade 6 content coverage*⁴⁷ (across grade framing over pacing) measured as the number of Intermediate Phase topics covered in grade 6 and as the number of grade 6 topics (0.93). *Grade 5 content coverage* measured as the number of Intermediate Phase topics covered in grade 5 and the number of grade 5 topics covered (0.98) were also very highly correlated. In other words, it seems that where content coverage in general was high, learners tended to cover more sub-topics at the expected level for their grade.

Fairly high correlations were also evident for the variable for *curriculum coherence* (across grade framing over sequencing) and *grade 6 content coverage* (across grade framing over pacing) measured as the number of Intermediate Phase topics covered in grade 6 (0.56) as well as the number of grade 6 topics (0.55). Furthermore, *content exposure* measured as the number of pages in the grade 6 workbooks correlated with *grade 6 content coverage* measured as the number of Intermediate Phase topics covered in grade 6 (0.43) and with the number of grade 6 topics covered (0.34), as well as with the variable for *curriculum coherence* (0.32). In other words, the data indicated an association between content exposure /'time on task', content coverage (both across grade framing over pacing variables), and curriculum coherence (across grade framing over sequencing variable).

Interestingly *content exposure* measured as the number of pages in the grade 6 workbooks also correlated with *grade 5 content coverage* measured as the number of Intermediate Phase topics covered in grade 5 (0.32) and the number of grade 5 topics covered (0.4). It was therefore evident that quite a few of the explanatory variables for OTL were correlated with each other and multi-collinearity was likely to occur, stepwise regression was used in an attempt to deal with this together with the dropping of the measure of the number of Intermediate Phase topics covered in grade 5 and in grade 6.

⁴⁷ For the statistical analysis of the variable 'content coverage', the model used was a simple count of 'whether or not' there was evidence that each of the possible 221 Intermediate Phase sub-topics on the Framework had been taught in the first three terms of 2003.

The *categorical* variables for *exposure to word problems* and the extent to which all learners in each class were equally *engaged* with mathematics in the three observed lessons were also examined in terms of their relationships with achievement gain. These relationships were explored using boxplots. The boxplots in figures 6 & 7 show that neither of the variables had an effect on achievement gain although a barely discernible pattern is very slightly evident.

Figure 6: Achievement gains by exposure to word problems

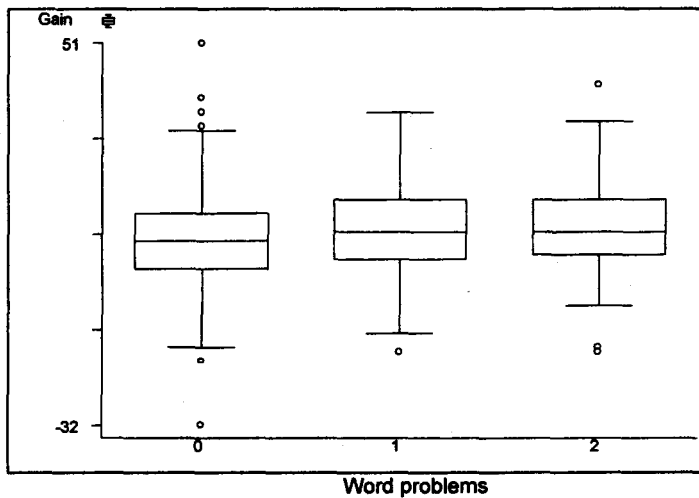
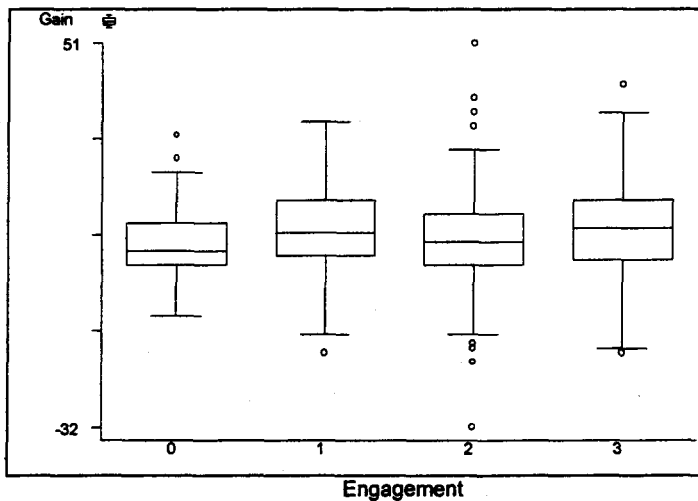


Figure 7: Achievement gain by engagement

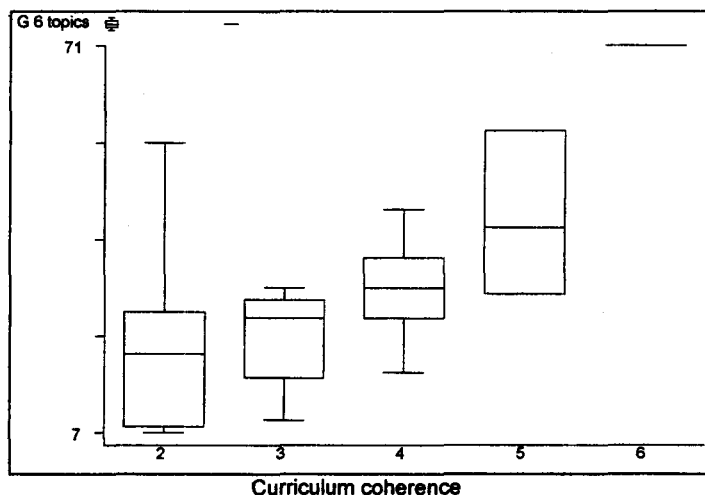


This could be because these variables were too crudely measured.

The relationship between *curriculum coherence* (across grade framing over *sequencing*) and across grade framing over pacing or *grade 6 content coverage* was also examined. The resulting boxplot (figure 8) below showed a very clear pattern with higher *curriculum coherence* being associated with higher *content coverage* (the median or central tendency as indicated by the line in the boxes rises quite steadily) suggesting that good logical across grade framing over

sequencing can lead to more coverage, that is, an increase in across grade framing over *pacing*.

Figure 8: Grade 6 content coverage by curriculum coherence



2.2.2 Model building

As stated earlier, the pre-test score was included to adjust for the starting level of the learners. The stepwise regression resulted in three variables – *level of cognitive demand* (a measure of ‘content by cognitive demand’), *learner absenteeism* (a ‘content exposure’ measure), *across grade framing over sequencing* (the ‘curriculum coherence’ variable) being significant. However, one of these variables, *across grade framing over sequencing* had a coefficient with an unexpected negative sign. This suggested that an increase in the rating for *curricular coherence* (good sequential development of mathematics topics) was associated with a decrease in achievement gain. This interpretation was counter-intuitive and examined further.

Firstly the 95% confidence interval included zero (the p-value was 0.121). Examining the boxplot for achievement gain by *curriculum coherence* revealed a fairly constant relationship with the exception of *curriculum coherence* rated as 6 (that is, as reflecting good sequential development of mathematics topics) which had the lowest average achievement gains. Only one class of learners had a rating of 6 for *curriculum coherence* and if some other factor had negatively affected the achievement gain of that class, this could have resulted in the counter-intuitive interpretation. The model was therefore refitted excluding the one class with a *curricular coherence* score of 6. This resulted in the *curriculum coherence* variable having a

p-value of 0.265 and no longer being significant. The variable was therefore excluded from the model.

The underlying assumptions of the model were first checked before going on to interpret the coefficients.

2.2.3 Model checking

The underlying assumptions of multiple linear regression were checked by examining the distribution of the residuals. As the residuals should be approximately normally distributed with a mean of zero and with constant variance, signs of non-normality or non-constant variance were looked for. The graphs for the final model used can be found in Appendix 17.

Both the histogram and the normal probability plot indicated that the residuals were approximately normal. Plotting the residuals against the fitted values showed that the variance of the residuals appeared to be constant. The residuals were also plotted against the two explanatory measures, *cognitive demand* and *absenteeism*. The residual variance appeared to be fairly constant for *cognitive demand* but definitely not constant for the *absenteeism* measure with the spread of the residuals being wider for smaller values of *absenteeism*.

The *absenteeism* measure was very positively skewed, that is most learners had fairly low absenteeism levels. This skewness was probably the reason for the non-constant residuals. Thus the *absenteeism* measure was transformed by taking its log and the new measure was then included in the model.

The new model with *logabsent* included was rechecked. The distribution of the residuals remained very much the same with regards to normality and constant variance (both against the fitted values and against *cognitive demand* - see Appendix 17). The transformed variable was plotted against the residuals and it appeared as if the transformation improved the problem of non-constant variance. The measure *logabsent* was therefore included in the model in place of *absenteeism*.

2.2.4 Model interpretation

The significant measures are displayed on Table 20 below together with their coefficients, standard errors, p-values and confidence intervals:

Table 20: Output of Model 1

<i>Variable</i>	<i>Coefficient</i>	<i>Std Error</i>	<i>P-value</i>	<i>95% Confidence Interval</i>
<i>Cognitive demand</i>	0.66	0.13	0.000	(0.38 ; 0.93)
<i>Logabsent</i>	-0.24	0.12	0.05	(-0.48 ; 0)

A one unit increase in the *cognitive demand* rating is associated with an increase in achievement gain of 0.66 points, holding all other measures constant. A 5 unit increase in *cognitive demand* would therefore be associated with a 3.3 point increase in achievement gain.

A one unit increase in *logabsent* (a 2.7 day increase in absenteeism) is associated with a decrease in achievement gain of 0.24 points, holding all other measures constant. A 2 unit increase in *logabsent* (a 7.4 day increase in absenteeism) would therefore be associated with a 0.48 point decrease in achievement gain.

The model was also refitted without the pre-test score to get an idea of its confounding effect. Ignoring the starting level of the learner led to the coefficients of *cognitive demand* and *logabsent* being overestimated by 7% and 25% respectively.

2.2.5 Checking outliers and influence

Figure 13 in Appendix 17 also showed the presence of 2 clear outliers (learners 764 & 841) along with several other outlying observations (learners 250, 851, 218, 401). These are examined closer by looking at their profiles on Table 21.

Table 21: Outliers from Model 1

<i>Learner #</i>	<i>Gain</i>	<i>Cognitive Demand</i>	<i>Logabsent</i>
218	-16	22	0.698
250	42	19	0.698
401	-16	21	1.947
764	-32	13	1.947
841	51	22	2.198
851	39	22	2.304

It is best to interpret this in light of the summary statistics of these variables on Table 22.

Table 22: Summary statistics: Model 1

	<i>Gain</i>	<i>Cognitive Demand</i>	<i>Logabsent</i>
<i>Mean</i>	9.96	19.9	1.09
<i>Min</i>	-32	9	-4.61
<i>Max</i>	51	27	4.19

Learner 218 had a negative gain but with an above average *cognitive demand* value and a fairly low value for *logabsent*. The model therefore cannot explain this person's poor performance.

Learner 401 also had a negative gain with an above average *cognitive demand* value and a slightly high value for *logabsent*.

Learner 764 had the worst gain in the sample of -32, a fairly low *cognitive demand* value, and a slightly high value for *logabsent*. This person's profile does not explain why he/she did so badly.

Learner 250 experienced a high gain with fairly average values for the 2 explanatory values.

Learners 841 and 851 both had high gains associated with slightly higher *cognitive demand* and *logabsent* values.

The outliers therefore consist of the extreme cases in the sample, in other words, those people that did very badly or very well. The profiles of these people in terms of the two explanatory measures do not provide sufficient information for the model to fit these cases well. This is not surprising since the model only explains slightly less than 10% of the variation in achievement gain and using only these two measures will not result in accurate predictions of achievement gain.

Influential observations were checked for by generating both Cook's Distance, and DFBETA statistics. No highly influential observations were found.

To recap: The modeling of predictor variables of ‘Opportunity-to-Learn’ confirmed the importance of ‘content by cognitive demand’ and ‘content exposure’ for achievement gain. Individual level data on absenteeism support the notion that more time spent in mathematics classes is related to achievement gain. However, the fact that the regression analysis showed no significant relationship between content coverage and achievement gain was rather unexpected given that OTL measured as content coverage and content exposure is the only classroom variable found to be significantly related to achievement growth in international studies.

3. EXPLORING THE RELATIONSHIP BETWEEN OVERALL ACHIEVEMENT STATUS AND OTL

The descriptive data had revealed evidence of slow curricular pacing across grades 5 and 6 signalling that learner under-preparedness was a cause for concern. A cursory examination of data on the average gain for each class over the school year suggested that, whilst the average gain was not generally greater for those classes where content coverage in both grade 5 and 6 was high, the average pre-test and post-test score for classes with higher coverage in both grades tended to be higher relative to other classes. Although as explained in section 2.3 of Chapter 4, I had made the research decision to focus on the relationship between the mathematics gains of the sample of 1001 learners and the key explanatory variables, I had also considered whether the effects of OTL may not in fact ‘show up’ in a ‘before and after’ measure such as gain because the effects accumulate over a longer period of time as is asserted by Schmidt & Burstein (1992) and Rowan, Correnti, & Miller (2002). This together with the counter-intuitive findings in the regression modeling led me to hypothesize about whether OTL might function differently and that an alternative analysis and research design might show the cumulative effects of across-grade pacing on achievement growth. I decided to investigate whether levels of *curricular pacing* were associated with mathematics achievement scores rather than gain across a single year.

With this in mind, the relationship between the pre- and post-test scores and levels of ‘content coverage’ in grade 5 and 6 was explored. Before this was done, the distribution of the pre- and post-test scores and the relationship between the pre- and post-test scores was examined.

3.1 Distribution of the pre- and post-test score

Table 23 summarises the distribution of the pre-test scores and post-test scores of the 1 001 learner.

Table 23: Summary statistics of pre- and post-test scores

	<i>Mean score</i>	<i>Median</i>	<i>Mode</i>	<i>SD</i>	<i>Min score</i>	<i>Max score</i>
<i>Pre-test</i>	31	26	9	20.1	1	103
<i>Post-test</i>	41	37	41	23.4	0	106

The standard deviation indicates that scores are distributed quite widely within the sample. Histograms show that both the pre- and post- test scores are positively skewed, that is, the number of lower scores is relatively higher than the number of higher scores. This confirms quite high levels of under-achievement for the sample at the beginning and at the end of the school year.

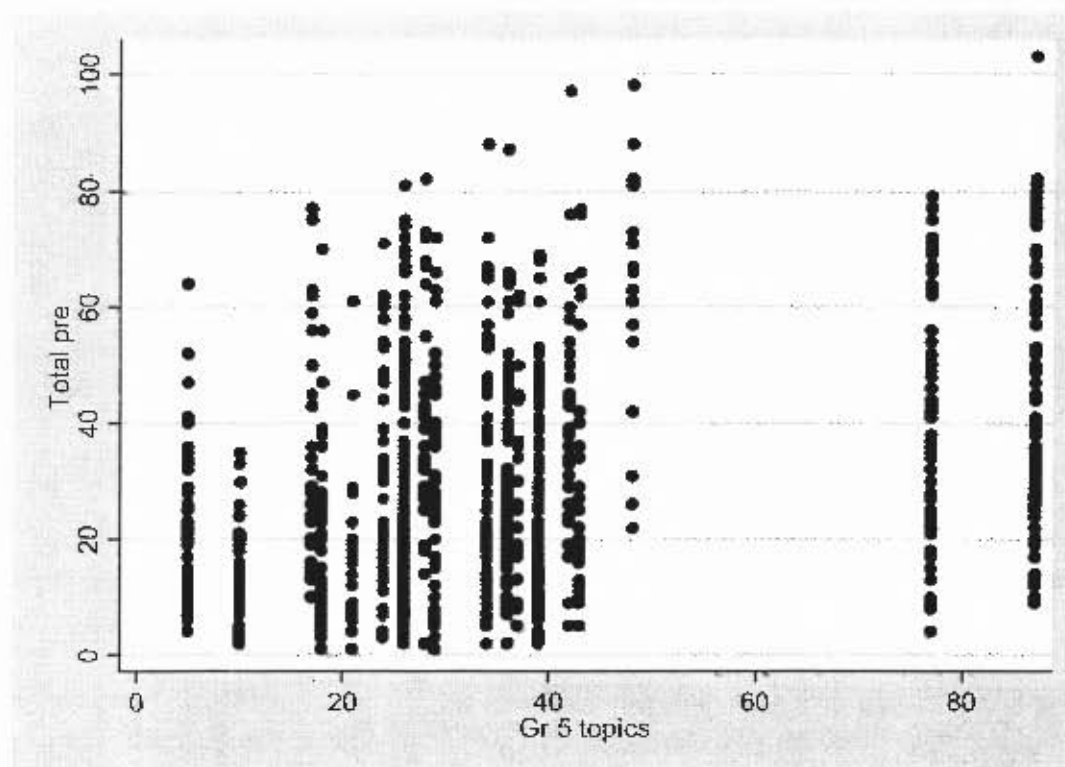
3.2 Relationship between the pre- and post-test score

The *pre-test score* is positively associated with the *post-test score*, showing that, in general, learners who did well on the pre-test score also tended to do well in the post test score. A Spearman's correlation coefficient of 0.91 indicates that this association is strong.

3.3 Relationship between the pre- and post-test scores and content coverage

The relationship between the pre-test score and coverage of grade 5 topics was then investigated to see whether coverage of grade 5 topics affected the pre-test score or starting level of the learners. The pre-test score had a correlation of 0.35 with the grade 5 topics suggesting a positive relationship. This was examined further with the following scatterplot (figure 16.1) which suggested a weak pattern with higher average pre-test scores tending to be associated with higher grade 5 topic coverage at any rate up until coverage of 48 topics. Only two schools involving 6 classes covered more than 48 topics. A slightly downward trend is evident when coverage is higher than 48 suggesting a quadratic relationship, that is, at a certain point, coverage may have been too fast for learners or teachers may have tried to cover too many topics with little depth.

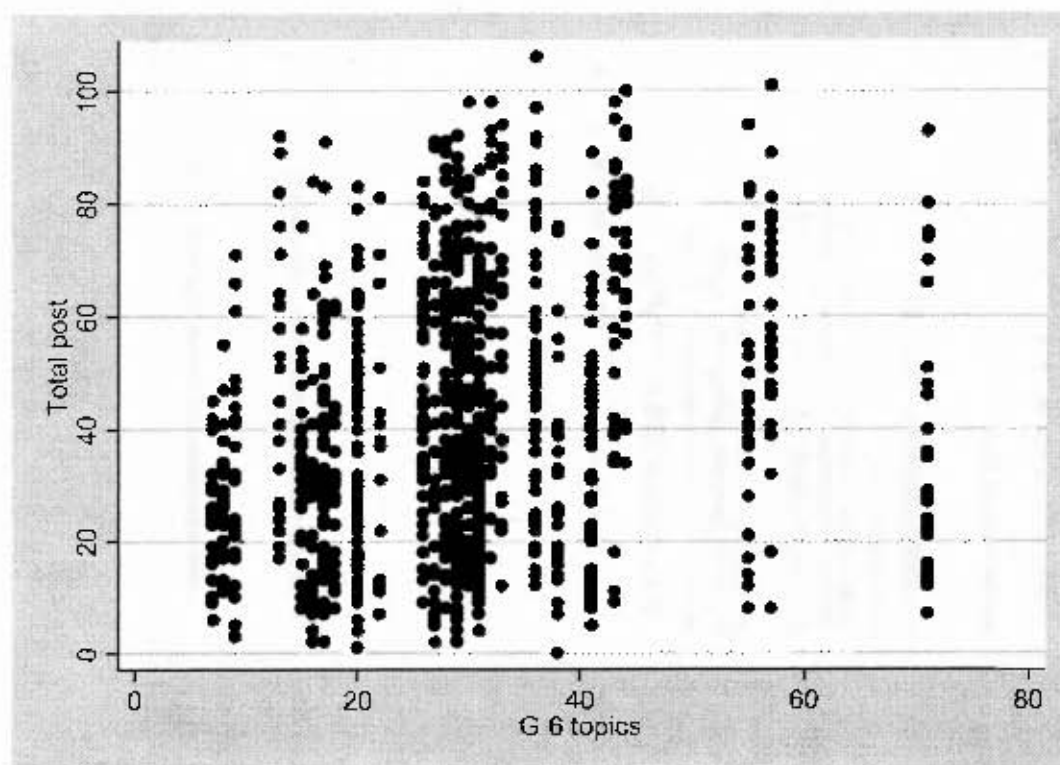
Figure 16.1: Pre-test score by number of grade 5 topics covered



The pre-test score was then regressed on the number of grade 5 topics covered in grade 5 (out of a possible 125) and this resulted in grade 5 topic coverage being highly significant (pvalue of 0.001) with a positive coefficient of 0.32 (95% confidence interval of 0.24 to 0.4) indicating consistent signs of a positive relationship. Although the effect size is small, and no causal relationship can be inferred, it is highly significant and suggests evidence that greater coverage of topics in earlier grades (across grade curricular pacing), at least up to a certain point, prepares learners better for subsequent grades.

The relationship between the post-test score and coverage of grade 6 topics in grade 6 (out of a possible 130) was also investigated to see whether topic coverage in grade 6 affected the post-test score or end level of the learners. The post-test score had a correlation of 0.23 with the number of grade 6 topics covered in grade 6 suggesting a positive relationship. A scatterplot (see figure 16.2 below) suggested a modest pattern with higher average post-test scores tending to be associated with topic coverage up to a certain point.

Figure 16.2: Post-test score by number of grade 6 topics covered



The post-test score variable was then regressed on grade 6 topic coverage and this too resulted in content coverage being significant (pvalue 0.025) with a positive coefficient of 0.18 (95% confidence interval of 0.02 to 0.34).

To recap: *Curricular pacing* appears as a potential variable for exploration, not in relation to achievement gain as expected, but in relation to overall *achievement status*. Data suggest that, up to a point, greater across grade/s content coverage could be associated with higher mathematics scores rather than increases in achievement gain across a single school year. The weak association in this study is not too surprising when one considers that we are looking at naturally occurring differences in curricular pacing where even the best classes were not exposed to optimal levels of curricular coverage.

The indication that content coverage may be related to overall achievement status as opposed to gain is most interesting. It suggests the idea that greater content coverage over a number of school years (curricular pacing) may be associated with higher mathematics achievement scores rather than to increases in *achievement gain* across a single school year. Although this study was not set up to investigate the 'cumulative' effect of curricular pacing has on

‘overall’ growth in achievement – data signal that this is an avenue for future study. The data exploration intimates that curricular pacing may have an across grade effect which is not necessarily evident when one examines gain within a year in a model using only pre- and post-test scores.

4. RESUME OF THIS CHAPTER

Descriptive results for the four key dimensions of the OTL construct, namely ‘content coverage by cognitive demand’, ‘content exposure’, ‘curricular coherence’, and ‘curricular pacing’ showed that

- for 71% of the learners engagement with mathematics content was mostly at procedural levels with, at most, a low degree of engagement with underlying principles
- 76% of the learners apparently had no or low levels of exposure to word problems.
- engagement of the entire class in the mathematics work was evident across all three lessons observations in 58% of the cases
- on average learners were absent 8 days
- on average the number of pages of work in learners’ workbooks was 121 pages.
- curricular spread of outcomes across the three terms for 50% of sample was deemed good, however. curricular sequencing across the three terms was deemed very poor or poor for 94% the sample
- most grade 5 and 6 learners spent more time on sub-topics they were expected to have covered in earlier grades than they did on sub-topics at the level expected for the grade. Data appear to mirror Smith, Smith & Bryk’s (1998) findings in the US described in *Setting the Pace: Opportunities to Learn in Chicago Public Elementary Schools* where a ‘steady exposure to slow pacing’ within and across grades appeared to be leaving certain learners ‘farther and farther behind’ (ibid: 2).

Statistical data exploration showed the distribution of the mathematics gain of the sample to be fairly symmetrical, approximately normal with some extreme values on both the lower and upper end.

Modeling using only the predictor variables of ‘Opportunity-to-Learn’ to discover which if any of the OTL measures are significantly related to achievement gain, showed a relationship

between an increase in *content by cognitive demand* and an increase in achievement gain. Modeling also showed a relationship between an increase in learner absenteeism (*a content exposure/time on task variable*) and a decrease in achievement gain. However, the significance of these variables in the relationship with achievement gain still needed to be tested in a model which combined all the significant OTL, 'type of pedagogy' and learner background variables to establish which of the variables from each of the 'explanatory constructs' contributes the most to increases or decreases in gain (see Chapter 7).

An examination of the distribution of the pre- and post-test scores showed that both the pre- and post-test scores are positively skewed. In other words, the number of lower scores is relatively higher than the number of higher scores. Exploration of the relationship between the pre- and post-test score showed that, in general, learners who did well on the pre-test score also tended to do well in the post-test score.

Data exploration of the relationship between the *pre- and post test scores* (learners' overall achievement status) and *content coverage* indicated a possible weak pattern with higher average pre-test scores tending to be associated with higher grade 5 content coverage and higher average post-test scores tending to be associated with higher content coverage in grade 6 content. Although no obvious inferences can be made, the unanticipated finding indicates that greater coverage of topics in earlier grades could be related to learner's overall achievement growth as opposed to growth across a single year. It suggests that higher mathematics achievement scores could be associated with higher *curricular pacing* over a number of school years rather than with increases in achievement gain across a single school year. The implication is that the across grade effects of OTL need to be considered in a different model which assesses cumulative effects of curricular pacing on achievement over a much longer period of time.

A related findings from the data exploration is that the relationship between *curriculum coherence* (across grade framing over *sequencing*) and across grade framing over pacing (grade 6 *content coverage*) showed a very clear pattern with higher *curriculum coherence* being associated with higher *content coverage* suggesting that good logical macro *sequencing* can lead to more coverage, that is, an increase in macro pacing. Further data exploration showed that *content exposure* measured as the number of pages in the grade 6 workbooks correlated with *grade 6 content coverage* measured as the number of Intermediate Phase

topics covered in grade 6. This implies that more 'time on task' in class could also be related to higher post-test scores though an increase in coverage.

Chapter 6 provides a descriptive analysis of learners' exposure to pedagogical practices as well as the statistical results of modeling the relationship between 'type of pedagogy' and achievement gain.

Chapter 6

DATA ANALYSIS: 'TYPE OF PEDAGOGY'

The first section of this chapter explains how a more empirically-based analytical framework was developed for the analysis of 'type of pedagogy'. Section 1 also provides a descriptive analysis of 'type of pedagogy' and the thirteen elements of pedagogical practice. The second section provides results from the second of the series of four regression models, modeling variables from the 'type of pedagogy' construct to discover whether pedagogical type and/or particular elements of practice are significant for achievement gain.

1. DESCRIPTIVE RESULTS: 'TYPE OF PEDAGOGY'

As outlined in Chapter 4, pedagogical practices in the classroom were measured in relation to the following thirteen key elements derived from Basil Bernstein's theoretical and conceptual framework. At the level of the *regulative context*, pedagogical practices were measured in terms of the degree to which

- the boundary between the teacher's and the learners' space is distinct or 'blurred';
- the boundary between learners' spaces is distinct or 'blurred';
- the hierarchical relation between the teacher and learners is 'masked' or clear;
- the hierarchical relations between learners are 'masked' or clear;
- communication relations between the teacher and learners are opened or closed;
- communication relations between learners and their peers are opened or closed.

At the level of the *instructional context*, pedagogical practices were measured in terms of the degree to which

- the boundary between mathematics and everyday discourse is distinct or 'blurred';
- the boundary between mathematics discourse and the discourse of other subjects is distinct or 'blurred';
- the teacher controls or learners *appear* to have control over micro selection (selection within lessons);
- the teacher controls or learners *appear* to have control over micro sequencing;
- the teacher controls or the learners *appear* to have control over micro pacing;
- the criteria for evaluation (recognition rules) are implicit or explicit *a priori*;

- the criteria for evaluating texts (realisation rules) are implicit or explicit;

In the lesson observations the thirteen internal features of 'type of pedagogy' were measured through the use of four indicators of the strength of their classificatory (power) or framing (control) relationships. The indicators drew primarily on Bernstein's theoretical framework. Strong values of framing or classification that is, F+/C+, were represented as F1 or C1 and very strong values that is, F++/C++, as F2 or C2. Weak values of framing or classification that is, F-/C-, were represented as F3 or C3 and very weak values that is, F--/C- -, as F4 or C4.

As explained in the methodology chapter, Chapter 4, the lesson observation schedule was open to a certain extent in that raters were required to exercise a degree of judgment in interpreting the indicators. In order to validate ratings and field notes obtained for each teacher's lessons, as far as was possible lessons were rated by different raters in each of the three terms. After the three lesson observations for each class had been rated, field notes and ratings for each of three lessons were compared looking for similarities and differences to ascertain whether ratings changed significantly with different raters or whether instructional practices changed significantly in different lessons or over time as the year progressed.

It was found that ratings varied mainly in relation to the strength of the value of classification or framing (that is, - or - -) rather than in relation to the value itself (that is, - or +). Consequently, for analysis purposes, the four ratings of (very weak C/F1 and weak C/F2 framing or classification) or (strong C/F3 and very strong C/F4 framing or classification) for each element were collapsed into two categories so that the preferred approach for each element of practice could more easily be characterised in terms of weak or strong classification or framing. If the approach was predominantly weak framing/classification, an element was given a new rating of C/F1 (for - or --) and if the approach was predominantly strong framing or classification, an element was given a rating of C/F2 (for + or ++). In other words, the four original categories or indicators were collapsed into two main categories or indicators (weak or strong). Collapsing the ratings made it possible to establish whether ratings indicated that similar patterns of practices were at work across at least two of the three observed lessons so that this could then be taken as indicative of learners' exposure to a more general pedagogical practice.

The idea was to obtain an overall rating for the regulative context and an overall rating for the instructional context and to combine ratings for both dimensions to obtain the 'holistic' rating characterizing the 'type of pedagogy' made available to respective learners. In other words, the intention was to assess 'type of pedagogy' as a whole. A high rating would mean that the 'type of pedagogy' was judged to be aligned with learner-centred approaches (weak classification and framing) whilst a low rating would mean that the pedagogical type was judged to be aligned with teacher-centred approaches (strong classification and framing).

The classroom observation instrument used for data collection was designed with a model considerate of streamlining larger-scale data collection on 'type of pedagogy' rather than capturing detailed differences in learners' exposure to pedagogical practice. However, my own empirical observations and the information provided in the other raters' field notes provided a more nuanced understanding and description of the kind of teaching practices learners were experiencing in their mathematics lessons than those provided in some of the indicators on the observation schedule. What became clear when I examined field notes on the lesson observations was that a more empirically-based analytical framework was needed for the all the framing elements and two of the classificatory elements.

Firstly, indicators for weak and strong framing over micro selection, sequencing and pacing needed to be revised so that they more accurately reflected the empirical data. Secondly, additional new indicators needed to be formulated for nine of the elements in interaction with raters' field notes and empirical observations on weak framing and classification.

1.1 A more empirical framework for the analysis of 'Type of Pedagogy'

The analysis of the available empirical data on framing over *micro selection, sequencing and pacing* showed that the majority of the grade 6 teachers did not use the 'truly' learner-centred approaches⁴⁸ provided in the examples for the indicators on the observation schedule. The original indicators suggested that weak framing involved choice or options on the part of learners whilst strong framing involved no choice. In reality learners in only one class had a

⁴⁸ Although the observation instrument had been piloted for variability prior to the study, it was piloted in contexts where variations were not 'naturally occurring' at school where an intervention was promoting learner-centred approaches involving learner choice and a thematic approach to integrating mathematics with other school subjects. It is possible that teacher in the sample schools decided that it was not practicable to use these learner-centred approaches to teach mathematics in response to shifts in curriculum policy (in particular the RNCS) and the introduction of systemic testing in the Western Cape.

choice when it came to selecting, sequencing or pacing of activities, materials and/or contents⁴⁹. Evidence from the other observations showed that variation in relation to weak or strong framing lay not so much in whether or not learners had choices but rather in whether or not learners influenced decisions around micro selection, sequencing or pacing activities, materials, or contents. More specifically, variation in weak and strong framing was most starkly evident when the teacher determined selection, sequencing and pacing without adjusting these in ways that were responsive to learners' levels of ability and progress. Indicators for micro selection, sequencing and pacing were thus revised in interaction with the empirical data. To illustrate this, the new indicators developed to analyse framing over micro pacing are shown on Table 24.

Table 24: New indicators developed to analyse framing over micro pacing

WEAK FRAMING F- (1)	STRONG FRAMING F+ (2)
Learners have a degree of influence over decisions around pacing of the contents, activities or materials with the teacher adjusting pacing according to the average learners' rate of progress.	The teacher determines the pacing of contents, activities or materials and keeps to time limits without adjusting pacing according to the average learners' rate of progress even when most learners cannot keep up.

Framing in F1 is constrained by and responsive to the average learners' rate of progress, whilst framing in F2 is not.

Secondly, what was also evident, was that, whilst in general, the observation model worked fairly well in relation to providing a common framework for characterising each element in terms of weak and strong framing or classification, it also presented pedagogies in ideal-typical terms and did not capture other practices anomalous to or outside of those in the indicators. Field notes from the empirical observations suggested evidence of versions of weak framing and classification not encapsulated in the indicators for each element. For example, in some lessons the principles underpinning weak framing over selection, sequencing and/or pacing were 'barely discernible' or almost indiscernible within lessons. Decisions around framing over selection, sequencing and/or pacing apparently related neither to adjustments made in relation to the average learners' capabilities or progress nor to grade level expectations. Selection and pacing of contents, activities or material was very loosely

⁴⁹ However, in this classroom learner choice appeared to be 'unconstrained'. This is illustrated in an extract from field notes in Appendix 15.

bounded - as is indicated in the following extracts from brief field notes. It is important firstly, to note that extracts from raters' notes are not 'raw data' but reconstruction or interpretations of the observations, and secondly, that evidence of particular practices are described as the most 'general state'.

Illustrative extracts from field notes of 'barely discernible' selection, sequencing and pacing.

Micro Selection

The lesson started with oral 'drill' work on multiplication tables. The mental work comprised multiplication tables below 10 x 10. This was followed by representing and comparing common fractions. The teacher dealt with halves, quarters, eighths, etc. and mainly concentrated on developing a concept of the comparative size of the common fractions – concepts which most learners apparently already had. The class showed increasing signs of boredom and restlessness.

Micro Sequencing

The lesson started with times tables. This was followed by revision of work that would have been covered in earlier grades - specifically representing and comparing common fractions. More focus was given to consolidating and revising previous knowledge than new learning.

Micro Pacing

The pace was slow with much repetition of familiar work that the class had already mastered so that no time was left for learners to start the more complex written activity involving a fraction wall as the teacher had planned.

In her study of grade 1 classrooms, Hoadley (1999) similarly noted pacing that was insensitive to learner progress. Then in some lessons it seemed that the teacher's social status, authority or power was neither covert nor overt. Classification of the hierarchical relations between the teacher and learners seemed almost indiscernible. The teacher seemed powerless to determine the characteristics of the classroom context. In some lessons the hierarchical relations between individual learners were 'barely discernible'. Learners' pedagogical identities were apparently 'collectivised' to the extent that their individual statuses as mathematics learners were indistinguishable from each other. Classroom-based studies conducted in South Africa by Ensor *et al.* (2002) and Dowling & Brown (1996)

similarly noted the communalisation of learners' pedagogical identities in classrooms with low SES learners.

Field note comments on framing over the evaluation criteria showed that, in some lessons, where mathematics was embedded in everyday contexts, learners' responses were not used to draw out and elaborate on the evaluation criteria through discussion. In such lessons, variability seemed to rest not so much on differences in the strength of framing over the evaluation criteria and whether the criteria were explicit or implicit as on the fact that framing over the evaluation criteria was almost indiscernible. Field notes on the criteria for legitimate realisation of texts for evaluation showed incidences of learners' responses being treated as equally valid (rather than 'valuable') so that evaluation focused neither on what was 'present' nor on what was 'missing' from their products. As discussed in Chapter 1, a number of PEI studies similarly noted that teachers did not assist learners adequately with making the difference between the everyday context and the scientific conceptions explicit (Taylor & Vinjevoold, 1999b). Walkerdene (1982) comments from her observation of classes in the USA that the use of real world contexts must be done with great care if they are not to obscure the school knowledge learners are expected to learn. An extract from field notes in Appendix 18 provides examples of what was taken as indicative of 'barely discernible' framing relations.

In order to allow for more meaningful comparisons of teachers' pedagogical practices across lessons and classes and reflect important qualitative differences between learners' exposure to pedagogical practices, additional new indicators of 'barely discernible' for each framing element and two of the classification elements were formulated and used to modify and refine the model for data analysis. For example, the following indicator was formulated to show 'barely discernible' framing over the criteria for legitimate realisation of texts for evaluation: *The criteria for legitimate realisation of texts for evaluation are almost indistinguishable. Learners' responses or products are treated as equally valid and the teacher provides no hints or cues as to which responses or products are correct or more successful. Evaluation of focuses neither on what is 'present' nor on what is 'missing'*

In this way a more empirically-based instrument for analysis was developed where, firstly, for the purposes of the statistical analysis, ratings of 1 and 2 (for very weak or weak framing or classification) and 3 and 4 (for strong or very strong framing or classification) for each element of teacher's practices was initially collapsed in terms of whether they were

predominantly strong (rated as 2) or weak (rated as 1) classification or framing. However, nine elements were each also rated in terms of whether or not framing or classification was deemed ‘barely discernible’ (rated as 0). Thus, although the ratings from the lesson observations were classified in terms of whether a teacher’s preferred approach to an element of practice, for example pacing, was strongly framed or weakly framed, weak framing could also be given a rating of 0 for ‘barely discernible’ framing. To illustrate this, Table 25 provides the ratings used to analyse framing over pacing.

Table 25: Ratings used to analyse framing over micro pacing

FRAMING OVER PACING		
BARELY DISCERNIBLE FRAMING F (0)	WEAK FRAMING F- (1)	STRONG FRAMING F+ (2)
Framing over pacing is almost indistinguishable. Learners appear to have unconstrained control over pacing - the pace is very loosely bounded for most learners and in relation to curriculum expectations.	Learners have a degree of influence over decisions around pacing of the contents, activities or materials with the teacher adjusting pacing according to the average learners’ rate of progress.	The teacher determines the pacing of contents, activities or materials and keeps to time limits without adjusting pacing according to the average learners’ rate of progress even when most learners cannot keep up.

Nine of the thirteen elements of pedagogical practice were thus summarised as a rating of C/F0, C/F1 or C/F2 whilst four of the classification elements were rated as C1 or C2 (the boundary between mathematics and everyday discourse; mathematics and other subjects; teacher-learners space; and learner-learner space.) This made it possible to reflect similarities and differences between the pedagogical forms observed in each classroom and to examine the relationship between the ‘type of pedagogy’ and achievement gains.

The analytical framework for ‘type of pedagogy’ is provided in Appendix 19.

1.2 Descriptive analysis of ‘Type of Pedagogy’

This section summarises the percentage of learners who, according to the ratings and reports, for the most part apparently experienced each of the practices described on the instrument for analysis in their mathematics lessons. Table 26 uses Bernstein’s concepts of classification and framing to summarise the percentage of learners who for the most part experienced the practices on the framework in their mathematics lessons. Shading indicates the type of framing or classification experienced by the highest percentage of learners.

Table 26: Percentages of learners who experienced particular pedagogical practices

TYPE OF PEDAGOGY			
		Regulative context	
Relations between spaces		Weak classification (C1)	Strong classification (C2)
Teacher and learners		63% Classification of space in the classroom facilitates weakly framed social relationships between the teacher and learners and emphasises the teacher's position of power. The teacher and learners mostly share spaces. Learners continually move into the teacher's space to 'display' their answers or the teacher spends more time in the learners' space.	37% Classification of space in the classroom promotes strongly framed social relationships between the teacher and learners and emphasises the teacher's position of power. The teacher and learner mostly remain in their own spaces. Learners never or hardly ever entered the teacher's space to 'display' their answers on the board and/or the teacher spends more in his/her space.
Learners		66% Classification of space in the classroom facilitates weakly framed social relationships between learners. Learners share spaces with one another. For example, they are seated at desks or...	34% Classification of space in the classroom promotes strongly framed social relationships between learners. Learners' spaces are separated from each other. For example, learners are seated individually at desks in rows or in pairs at two-seater desks and each have their own material.
Relations between subjects/agents		Weak classification (C1)	Strong classification (C2)
Teacher and learners	5% The teacher's social status, authority or power is indiscernible. The teacher seems powerless to determine the characteristics of the instructional and regulative context. Learners rather than the teacher appear to determine the characteristics of the classroom contexts.	10% The teacher's social status, authority or power is covert. The fact that the teacher defines the characteristics of the instructional and regulative contexts is 'masked'. Learners appear to be self-regulating and to take personal responsibility for initiating actions and following routines themselves.	85% The teacher's social status, authority or power is overt. The fact that the teacher defines the characteristics of the instructional and regulative contexts is clear. The teacher openly regulates learners' actions and asserts her/his position of authority or power, for example, by frequently making sure that learners focus attention on him/her and wait for his/ her instructions or directions before acting.
Learners	39% Hierarchical relations between learners are indiscernible. Hierarchies between learners are neither clear nor 'masked'. Statuses are collectivised or homogenised to the extent that their pedagogical identities as maths learners are neither performance nor competence-based.	30% Possible hierarchies between learners are 'masked'. Learners' pedagogical identities as maths learners are based on shared competence established through equal participation in joint productions and/or equal inter-personal intervention from the teacher.	31% Hierarchies between learners are clear. Learners' pedagogical identities as maths learners are based on private performances used to differentiate learners in terms of those who are able to respond successfully and those who are not.

Table 26 cont.

Hierarchical rules	Barely discernible framing F0	Weak framing F1	Strong framing F2
Teacher-learner communication relations	2% Framing over teacher-learner communication relations is almost indiscernible. For example, learners call out and make unsolicited comments to the teacher about matters unrelated to mathematics to disrupt teaching and learning.	13% Teacher-learner communication relations are open. Learners initiate interaction with the teacher on their own accord by commenting, interjecting, asking questions about mathematics or requesting assistance from the teacher.	83% Teacher-learner communication relations are closed. Learners participate in teacher-learner interactions only when overtaken by the teacher, or when they are asked to contribute.
	16% Framing over learner-learner communication relations is almost indiscernible. For example, learners chat about matters unrelated to mathematics in their groups or copy each other's work when they are supposed to work alone.	42% Learner-learner communication relations are open. Learners have opportunities to interact and collaborate with one another.	42% Learner-learner communication relations are closed. Learners have no opportunities to interact and collaborate with their peers.
Relations between discourses		Instructional context Weak Classification C1	Strong Classification C2
Mathematics and everyday discourse		55% Mathematics knowledge and everyday knowledge are related. Everyday discourse or contexts are brought into the classroom. For example, through embedding mathematics knowledge in real world problems, the recognition of everyday knowledge to support conceptual development of mathematics knowledge or through the application of mathematics knowledge in real world problems.	45% Mathematics knowledge and everyday knowledge are unrelated. Everyday discourse or contexts are not brought into the classroom. No or only very superficial references are made to related everyday knowledge.
Mathematics and other school subjects		2% Interdisciplinary relations are promoted through the use of themes. Mathematics knowledge is integrated with other school subjects through themes.	15% Mathematics discourse is separated from the discourse of other school subjects. Interdisciplinary relations are not promoted. Mathematics knowledge is not integrated with other school subjects through themes.
Discursive rules	Barely discernible framing F0	Weak framing F1	
Selection	21% Framing over selection is almost indistinguishable. Learners appear to have unexplained control over selection - selection of contents, activities or materials is very loosely bounded. For most learners and for grade 6 curriculum requirements.	66% Learners appear to have a degree of influence over decisions around the selection of activities, materials, or contents with the teacher adjusting selection according to the average learners' level of capability.	11% The teacher determines the selection of activities, materials, or contents and uses pre-selected contents, materials or contents without adjusting selection according to the average learners' level of capability even when the work is too difficult for most learners.

Table 26 cont.

Relationship	Barely discernible framing	Weak framing	Strong framing
Sequencing	15% Framing over sequencing is almost indistinguishable. Learners appear to have unconstrained control over sequencing - the sequencing of contents, activities or materials is very loosely bounded for most learners and in relation to curriculum requirements.	77% Learners have a degree of influence over decisions around order of activities or contents with the teacher adjusting sequencing according to the average learners' level of progress, for example, by revisiting or revisiting work only when necessary for the learners.	8% The teacher determines the order or sequencing of activities, materials or contents and follows a pre-set order without adjusting sequencing according to the average learners' level of progress even when most learners are unable to progress.
Pacing	47% Framing over pacing is almost indistinguishable. Learners appear to have unconstrained control over pacing - the pace is very loosely bounded for most learners and in relation to curriculum requirements.	37% Learners have a degree of influence over decisions around pacing of the contents, activities or materials with the teacher adjusting pacing according to the average learners' rate of progress.	16% The teacher determines the pacing of contents, activities or materials and keeps to time limits without adjusting pacing according to the average learners' rate of progress even when most learners cannot keep up.
Criteria for evaluation	10% Framing over the evaluation criteria is almost indiscernible. The teacher does not use the exploration of contexts or problems to draw out and elaborate on the evaluation criteria.	18% The criteria for evaluation are implicit <i>a priori</i> . Access to the evaluation criteria is through explorations of contexts or problems and the teacher uses learners' efforts or responses (exploration and discussion) to draw out and elaborate on the evaluation criteria.	72% The criteria for evaluation are explicit <i>a priori</i> . Access to the evaluation criteria is directly through exposure of worked solutions and detailed demonstrations of procedures to follow <i>a priori</i> .
Texts for evaluation	5% The criteria for legitimate realisation of texts for evaluation are almost indistinguishable. Learners' responses or products are treated as equally valid and the teacher provides no hints or cues as to which responses or products are correct or more successful. Evaluation focuses neither on what is 'present' nor on what is 'missing'.	35% The criteria for legitimate realisation of texts for evaluation are implicit. The teacher provides hints or indicates which responses or products are more valuable or successful. Evaluation of texts focus on what is present rather than on what is incorrect and 'missing', and learners' products or responses are undifferentiated in terms of how (in what ways) they are unsuccessful/incorrect.	60% The criteria for legitimate realisation of texts for evaluation are explicit. The teacher judges responses or products as correct and incorrect, and uses error to identify and provide feedback on what is missing from incorrect answers. Evaluation focuses on what is incorrect and 'missing'. Learners' products or responses are clearly differentiated in terms of how (in what ways) they are unsuccessful/incorrect.

Information on Table 26 shows that no ideal types or modal pattern is evident for the sample. Nevertheless, the following main tendencies are identifiable – tendencies towards

- weak classification values for relations between learner-learner and teacher-learner spaces.
- strong classification values for hierarchical relations between teachers and learners
- strong framing over regulative discourse in relation to the communication relations between teachers and learners.

- ‘barely discernible’ or weak classification values for hierarchical relations between learners.
- ‘barely discernible’ or weak framing over regulative discourse in relation to communication relations between learners.
- strong classification values for relations between mathematics and other school subjects – mathematics knowledge was not integrated with other school subjects through themes in 98% of the cases.
- almost indiscernible or weak framing over instructional discourse in relation to micro selection, sequencing and pacing with pacing judged as unconstrained for 47% of the sample.
- strongly framed evaluative rules.

Tendencies in relation to classification values for relations between mathematics and everyday knowledge do not emerge clearly from the data. The tendency towards weak classification of teacher-learner spaces but strong classification values for hierarchical relations between teachers and learners provides further evidence that classrooms reflect ‘outward’ forms of learner-centred practice (Brodie *et al.*, 2002; Taylor in Schollar, 1999).

Overall the descriptive analysis shows that, in terms of strong/weak classification/framing, the internal features of the pedagogy made available to the sample of learners are relatively homogenous; however, with the exception of classification of relations between mathematics and other school subjects, there is evidence of sufficient variance for the statistical analysis. Section 2 presents the statistical analysis of the influence of the various pedagogic practices on learning gain.

2. STATISTICAL ANALYSIS: ‘TYPE OF PEDAGOGY’

This section provides the results for modeling ‘type of pedagogy’ or the various internal features of pedagogy as predictor variables to discover which if any of the measures emerge as significantly related to achievement gain. As 98% of the sample experienced a type of pedagogy where mathematics knowledge was not integrated with other school subjects through themes, this element has been dropped from the statistical analysis.

2.1 Modeling 'Type of Pedagogy'

2.1.1 Data exploration

Data exploration was carried out to identify potentially useful predictor variables and their relationship with the gain variable as well as to look at the relationships between the independent variables. Once again a correlation matrix was first generated for the various total variables. Since none of the pedagogy variables were even approximately normal, the matrix was used as a guide and any important correlations were checked by generating Spearman rank correlations.

The *total* ratings for the *instructional* and the *regulative* contexts were highly correlated (over 0.80) with *total* ratings for all the elements of 'type of pedagogy' (which is a combination of the instructional and regulative variables). In addition the *total* rating for the *instructional* context variable was correlated with the individual instructional variables and a similar pattern was evident with the individual components for the regulative context. This was not surprising and was not explored further due to the fact that 'type of pedagogy' was modelled separately using firstly the *total* regulative and instructional variables and secondly the individual components that comprised these totals. None of the *total* variables were highly correlated with achievement gain (all had spearman coefficients less than 0.1).

The individual elements of pedagogy were all binary (for four classificatory elements) or had 3 ordinal categories (for nine elements). So as to identify patterns of association and variables for the model, the relationships between the independent variables were explored using chi-squared tables and the relationships with the continuous achievement gain measure were explored by using boxplots (see tables 27.1-27.8 and figures 17-22 in Appendix 20).

The boxplots (figures 17-22) revealed a slight pattern of an increasing average gain with increasing framing levels of both *evaluation criteria* variables, these are: the degree to which the evaluation criteria (also referred to as *pre-task evaluation criteria*); and the criteria for evaluating texts for evaluation (also referred to as *post-task evaluation criteria*) are explicit (F2). The pattern was more marked for the explicit criteria for evaluating texts variable that is, where error was used to provide explicit feedback on what was missing from incorrect answers.

The *micro selection*, *sequencing* and *pacing* variables all showed a similar pattern with regards to the response variable with the highest gain levels being associated with weak framing within lessons (F1 - where learners apparently influenced decisions around selection/sequencing/pacing of activities, materials, or contents) and very similar levels being evident for 'barely discernible' framing (F0 - where pacing for example, was apparently very loosely bounded for most learners) and strong framing (F2 - where pacing for example, was apparently very tightly bounded for most learners).

A slight pattern was also evident with the *hierlearners* (the degree to which the hierarchies between learners are 'masked' or clear) variable whereby the lowest levels of gain were associated with 'barely discernible' classification (C0). In other words, the lowest gains were associated with a form of pedagogy where learners' pedagogical identities were communalised or homogenised to the extent that their individual status as mathematics learners appeared indistinguishable. No apparent differences were suggested between the weak and strong classification of hierarchical relations between learners (C1 and C2 – competence or performance-based identities).

A sequence of chi-squared tables (see tables 27.1-27.8 in Appendix 20) showed that all the pedagogy variables were related with each other (a statistically significant dependence existed). The variables that had a very strong dependence (Chi-squared stat greater than 300)⁵⁰ were focused on. This revealed that the three variables *micro selection*, *sequencing* and *pacing* had a strong association with each other and tended to have the same pattern, that is, the same types of framing were generally seen for these variables so that learners with strong framing over selection tended to have strong framing over sequencing.

The *post-task evaluation* variable had an association with both *micro sequencing* and *selection*. Strong framing over the criteria for evaluating texts (F2) was associated with weak framing over selection and sequencing (F1). 'Barely discernible' framing over the criteria for evaluation and the criteria for legitimate realisation of texts (F0) was associated with either 'barely discernible' framing or strong framing over selection/sequencing (F0 and F2). This suggests that issues of evaluation are associated with issues of micro selection and

⁵⁰ 300 is the test statistic. The degrees of freedom range from 2-4 for these chi-square tables. The associations are very strong even for a large sample.

sequencing. Responsive selection and sequencing (F1 -where learners appear to influence selection and ordering in that the teacher adjusted content or tasks in response to learners) within lessons appears to be related to evaluation practices. In particular, it seems that, by ascertaining learner error (F2), teachers are better able to adjust the order of content, tasks or material according to the average learners' level of capability and progress, for example, by revisiting or reviewing work if necessary or leaving out items that most learners have already mastered.

Approximately 85% of the sample experienced strong classification of *hierarchical relations between the teacher and learners* (C2) and strong framing over *communication relations between the teacher and learners* (F2). (Predictably these variables were strongly associated with 91% having strong classification/framing for both.) It is important to note that, because the study investigates naturally occurring variations, certain pedagogic practices, in particular the communication relations between the teacher and learners were not different for most learners in the analysis. This could explain why this element of the pedagogic practice does not emerge in the modeling as predictor variables for achievement gain (Morais & Pires, 2002).

A strong association was also evident with classification of *hierarchical relations between the teacher and learners* (the degree to which the hierarchical relations between the teacher and learners is 'masked' or clear) and framing over *learner-learner communication relations* (the degree to which communication relations between learners and their peers are opened or closed). As can be expected, there was also a strong association between classification of the *hierarchical relations between learners* and framing over *learner-learner communication relations*.

Lastly, there was a strong association between framing over *micro selection* and classification of *hierarchical relations between learners*. 'Barely discernible' framing (F0) or strong framing (F3) over *micro selection* is associated with 'barely discernible' classification (C0) of hierarchical relations between learners. This means that selecting content, tasks or materials that is unresponsive to learners' level of development is associated with communalising learners' pedagogical identities.

2.1.2 Model building

As explained in section 5 of the methodology chapter, when testing the main hypothesis, the pre-test score was included to adjust for the starting level of learners. A regression could not be run on both the *total* (instructional and regulative) variables and the individual elements due to colinearity. Therefore the model was fitted firstly with only the *total* pedagogy variables, and secondly with only the individual elements of pedagogy. The variables that were coded as either 'barely discernible'/weak/strong framing were converted to an appropriate set of dummy variables using the 'strong framing' category as the reference level.

The first model fitted the *total regulative* and *total instructional* variables (total ratings for the instructional and the regulative contexts) but neither was found to be significant (p-values of 0.8 and 0.62 respectively). This model was refitted using the combined variable *total pedagogy* (combined total for the instructional and the regulative variables) but this was still not significant (p-value of 0.29). This appeared to support the view that 'type of pedagogy' as a whole does not significantly influence achievement gain. The influence of individual features of pedagogy was thus explored instead.

Model building for the second model began with both a forward and a backward stepwise regression. A forward stepwise regression starts with an empty model. Independent variables with significant regression coefficients are brought into the regression equation one at a time starting with the variable that leads to biggest improvement to the model. A backward stepwise regression starts with a full model. Independent variables whose contributions to the model are least significant are then removed one at a time.

The forward regression resulted in the variables *micro sequencing*, *selection*, and *learner-learner communication relations* being significant whereas the backward regression resulted in the same variables with the addition of the two *evaluation criteria* variables. Since *micro selection* and *sequencing* were highly correlated we checked for multi-colinearity using the VIF command on a model fitted with both these variables. This showed that multi-colinearity was a real concern and therefore only one of these variables was used. *Micro pacing* also had a high correlation with *micro selection* and *sequencing* and so the combined term (of all 3) was tried but not found to be significant.

The data exploration revealed a pattern between the *evaluation criteria* variables and the *achievement gain* variable and these were therefore included in the final model despite being dropped by the forward stepwise regression. Furthermore the model appeared to be more stable by including *micro sequencing* compared to *micro selection* and consequently this was chosen. The variable *learner-learner communication relations* became insignificant, hence it was dropped. Finally interaction between the two *evaluation criteria* variables (the criteria for evaluation and the criteria for legitimate realisation of texts) was investigated but not found to be significant.

The underlying assumptions of the models were first checked before going on to interpret the coefficients.

2.1.3 Model checking

The graphs for the final model used can be found in Appendix 21 (figures 23-25). The residuals were found to be approximately normal with constant variance. Since all explanatory variables were binary, it was not necessary to check the residuals against the predictor variables.

2.1.4 Model interpretation

The significant variables together with their coefficients, standard errors, p-values and confidence intervals are displayed on Table 28.

Table 28: Output of Model 2

<i>Variable</i>	<i>Coefficient</i>	<i>Std Error</i>	<i>P-value</i>	<i>95% Confidence Interval</i>
<i>Evalcrit_pre_0</i>	-2.43	1.16	0.05	(-4.85 ; -0.001)
<i>Evalcrit_pre_1</i>	-3.03	1.05	0.009	(-5.21 ; -0.84)
<i>Evalcrit_post_0</i>	-2.93	1.57	0.076	(-6.2 ; 0.33)
<i>Evalcrit_post_1</i>	-3.02	1.52	0.061	(-6.2 ; 0.16)
<i>Micro sequencing_0</i>	2.95	0.83	0.002	(1.22 ; 4.67)
<i>Micro sequencing_1</i>	4.82	1.02	0.000	(2.7 ; 6.94)

Data show that responsive framing (F1) over the discursive rules (micro selection/sequencing/pacing) within lessons contributes to the biggest increase in gain. Compared to strong framing over *micro sequencing/selection/pacing* (F2), 'barely discernible' framing (*Micro Sequencing_0*) is associated with an increase in gain of 2.95 points, while weak or

responsive micro framing (*Micro Sequencing_1*) is associated with an increase of 4.82 points. The very high association of the *micro selection* and *pacing* variables with the *micro sequencing* variable means that they are essentially measuring very similar things. Hence one can infer the same type of effect.

Data show that, in relation to framing over evaluation criteria, weak framing over the evaluation criteria (F1) contribute to the biggest decrease in gain. Compared to strong framing over evaluation criteria, 'barely discernible' framing (*Evalcrit_pre_0*) was associated with a decline in gain of 2.43 pts, while weak framing (*Evalcrit_pre_1*) was associated with even more of a decline (-3.03) in gain. A similar picture emerged for the framing over the criteria for evaluating texts with 'barely discernible' framing (*Evalcrit_post_0*) being associated with a decline in learning of 2.93 pts and weak framing (*Evalcrit_post_1*) with an even greater decline of 3.02 pts.

2.1.5 Checking outliers and influence

Figure 25 in Appendix 21 reveals the same 2 clear outliers (learners 764 & 841) as the opportunity to learn model along with several other outlying observations that were also very similar to the previous model (learners 250, 851, 432, 218). These were examined closer by looking at their profiles on Table 29.

Table 29: Outliers from Model 2

<i>Learner #</i>	<i>Gain</i>	<i>Evalcrit_pre</i>	<i>Evalcrit_post</i>	<i>Sequencing</i>
218	-16	2	2	1
250	42	2	2	1
432	36	1	2	1
764	-32	0	1	2
841	51	2	1	1
851	39	2	1	1

Learner 218 had a negative gain despite having strong framing over criteria evaluation and weak framing over sequencing.

Learner 250 had a gain of 42 points with strong framing over evaluation and weak framing over sequencing. The model would have predicted a good gain for this person but cannot explain why the gain was so high.

Learners 432, 841, and 851 all experienced high achievement gain with a profile that included weak framing for one of the evaluation criteria.

Learner 764 had a profile that would not be expected to do particularly well due to the strong framing over sequencing and 'barely discernible' framing over evaluation criteria. However this learner achieved the worst result in the sample and the model could not predict why the outcome was so low.

All the outliers are learners with extreme outcomes, that is, those that did particularly well or particularly badly. This model consists of only classroom level variables and hence it was not surprising that it cannot explain the extreme cases well. Extending this model to include other individual level variables should lead to an improvement (see Chapter 7).

Influential observations were checked for by generating both Cook's Distance, and DFBETA statistics. No observations were found to be highly influential.

To recap: Modeling of 'type of pedagogy' variables confirms that achievement gain varies in relation to elements of pedagogy, specifically elements of the instructional context. The regression model signals the importance of weak/responsive framing over the discursive rules of micro selection, sequencing and pacing and strong framing over the evaluation criteria, particularly the criteria for legitimate realisation of texts.

3. RESUME OF THIS CHAPTER

This chapter elaborates on the development of a more empirically-based framework for analysing the thirteen elements of pedagogical practices for the regulative and the instructional context. Thus, although the analytical framework draws primarily on Bernstein's concepts of classification and framing, indicators are also derived in interaction with empirical data from the study. Firstly, the four original categories or indicators for classification and framing elements were collapsed into two main categories or indicators (weak or strong). Secondly, indicators for framing over micro selection, sequencing and pacing were revised to show that variation in relation to weak or strong framing lay in whether or not teachers adjusted selection, sequencing or pacing in ways that were responsive to learners' levels of ability and progress. Thirdly, additional new indicators of 'barely

discernible' framing (F0) were developed for the nine elements (seven framing elements and two classification elements).

Statistical modeling using only the overall rating for 'type of pedagogy' appears to support the view that pedagogical type alone does not significantly influence achievement gain. An exploration of the influence of the individual elements of pedagogy as predictor variables of achievement gain indicates that weak or responsive framing over the discursive rules (*micro sequencing, selection and pacing*) promotes *achievement gain* across an academic school year. The model indicates that gain is higher where learners influence decisions around selection, sequencing and pacing within lessons. More specifically, gain appears higher where the teacher apparently adjusts selection, sequencing and pacing of content, activities and materials in ways that are responsive to learners' levels of ability and progress.

Strong framing over the *evaluative rules*, particularly the criteria for legitimate realisation of texts (*post-task evaluation criteria*), is also associated with *increases* in *gain* in the model suggesting that this is a condition for learning for the sample. Learning was enhanced where teachers made the mathematics knowledge to be acquired clear by giving detailed expositions and illustrations and used error to provide feedback to make the criteria for legitimate realisation of texts for evaluation explicit. This appears to confirm the importance of the teacher 'clearly telling children what is expected from them' and, especially, 'of identifying what is missing in their textual production' (Morais & Pires, 2002: 8).

What is interesting is that *weak* framing over the *evaluative rules* is associated with a greater *decrease* in achievement *gain* than 'barely discernible' framing. That is, the decrease in achievement gain appears greater where the evaluative rules are implicit and the teacher provides hints or clues as to which responses are more valid than when the teacher accepts all responses as equally valuable and does not provide hints as to which responses are more appropriate or successful. The implication is that not only do learners in the sample not recognise or miss the implicit evaluative hints, clues and cues teachers provide, they appear to misinterpret or be confused by them. In the USA Lubienski (2004) similarly found that low SES learners struggled to pick up on the hints and clues she provided when using contextualised situations in her mathematics lessons.

Modeling also indicates that a trend is for strong framing over *micro selection/sequencing/pacing* to be worse than 'barely discernible' framing. The implication is that, although the level of mathematics content or tasks needs to be somewhat higher than what learners are able to cope with (Morais & Pires, 2002), a level that is pitched too high in relation to most learners' level of development as opposed to 'too low', has a greater negative effect on achievement gain. Furthermore, a strong association between framing over *micro selection* and classification of the *hierarchical relations between learners* suggests that 'barely discernible' framing over *micro selection* where the contents, activities or materials selected are unresponsive to learners' level of development and grade 6 requirements is associated with collectivising learners' pedagogical identities indicating that differentiation between learners is important for the specialisation of individual voices.

Modeling using all the 'type of pedagogy' variables helped identify which features of pedagogy appear to have a demonstrable positive or negative effect on gain for the sample. Elements of the *instructional discourse* emerge in the modeling as predictor variables for achievement gain. Modeling using only the 'type of pedagogy' variables shows that the biggest gains are produced by *weak* or *responsive framing* over the discursive rules of *micro selection, sequencing* and *pacing*, whilst the largest decreases in gains are associated with lack of clarity over the *evaluative rules*. For this sample of learners and their teachers, weak framing (F1) over the evaluative rules appears not to be able to specialise text. No elements of the *regulative discourse* emerge in the modeling as predictor variables for gain.

In Chapter 7 the significance of the *evaluation criteria* and *micro selection/ sequencing/ pacing* variables in the relationship with achievement gain is tested in a model combining all the significant variables from the various models for OTL, 'type of pedagogy' and selective individual level learner background variables. The aim is to establish which of the significant variables from each of two focus constructs are associated with increases or decreases in gain for the sample of low SES learners.

Chapter 7

DATA ANALYSIS: MODELING LEARNER BACKGROUND VARIABLES, THE COMBINED REGRESSION MODEL AND COMPARISON OF MULTIPLE LINEAR REGRESSION RESULTS WITH RESULTS OF HIERARCHICAL LINEAR MODELING

The aim of this study is to identify the effects of measures of ‘opportunity to learn’ and ‘type of pedagogy’ on the mathematics achievement gain of a sample of grade 6 learners from four Cape Peninsula districts whilst controlling for SES. Although the assumption is that the schools selected all serve learners with fairly homogenous socio economic backgrounds, the study also collected data on selective individual level background variables to discover their effect on gain.

Since the focus of the research is not on these variables, descriptive data on learner background characteristics showing frequencies and central tendencies for the sample are provided in Appendix 22 rather than in the main text. The first part of this chapter describes and presents results from the third in the series of regression modeling to identify those of the individual background variables that are significantly related to gain over the school year so that these can be included in the final model for the regression analysis. The second part of the chapter presents the fourth regression model combining all the OTL, ‘type of pedagogy’ and learner background variables that came out as significant for achievement gain in the three earlier models to see which variables contribute the most to increases or decreases in gain.

Finally, as multilevel statistical modeling is often considered a more appropriate technique when data is of a ‘nested’ nature such as learners ‘nested’ within classes, the fourth part of this chapter compares the results of the linear regression modeling with the results of hierarchical linear modeling (HLM). As explained in Chapter 4, a feature of this study is that, although the individual learner is the unit of analysis, learners within the same classes received the same value for all of the ‘type of pedagogy’ and all of the OTL measures with the exception of one individual level variable- the number of days each learner was absent (*Log Absent*). In contrast, all the learner background variables (such as gender, whether both parents live with them, or how often learners speak English at home) are individual level

variables with the exception of one class level variable – whether the learner wrote the test in English as opposed to Afrikaans (*Test language_English*). The idea behind conducting the HLM is to see whether the coefficients for the significant variables change when the individual and class level data are modelled at two separate levels.

1. MODELING LEARNER BACKGROUND VARIABLES

This section reports on results from modeling only learner background variables to see which of the variables identified in the literature review are significant for gain and should be included in the combined model.

1.1 Data exploration

Most of the learner background variables were either ordinal or binary. There were two continuous variables, *mobility* (the number of years learners had lived in their present neighbourhood or area) and *homework* (the number of people at home or outside of school learners felt they could call on for help), both of which had positively skew distributions. The various binary and ordinal variables were not explored further.

1.2 Model building

As stated earlier, the pre-test score was included in all model building to adjust for the starting level of the students. All the background variables were put into a stepwise routine. Fourteen variables were found to be significant. Of these, four were from a set of dummy variables relating to the main caregiver, whether he/she had finished high school, whether he/she attended a school meeting, and how often he/she gets together with the community. Due to missing values, the stepwise routine was performed on only 471 observations.

The model was then fitted again with only the significant variables and including the full sets of dummy variables. This model now turned out to be for 803 observations and resulted in two variables, *gender* (whether the learner is a girl or boy) and *Afrikaans speaking* (how often learners spoke Afrikaans at home) becoming insignificant. The insignificant variables were therefore dropped from the model. In addition the *carer community involvement* dummy variable (how often the learners' mother or main caregiver gets together with other people to do or talk about things) was also dropped. This was because, although the category 'sometimes' was different from 'often', the category 'never' was not significantly different and this seemed counterintuitive.

Interaction terms were then created to check for interaction between the *Test language_English* variable (whether the language in which the test was written was English) and the *English* and *Afrikaans speaking* (how often learners speak English/Afrikaans at home) variables but were not found to be significant (p-values of 0.84 and 0.38 respectively). This resulted in a final model (model 3) with a total of 16 variables (including the dummy variable sets) and with a R squared of 13.7%.

1.3 Model checking

The residuals from Model 3 were found to be approximately normal and to have constant variance (see Appendix 23). The variance of the residuals was also checked across each predictor variable and it was found that the residuals were not constant over the variable *homework* (how many people outside of school could be consulted by the learner for help with school work).

The *homework* variable was very positively skewed, that is, most learners had few people that they could consult. This skewness was probably the reason for the non-constant residuals and the *homework* variable was therefore transformed by taking its log. The new variable was then included in the model but not found to be significant and was subsequently dropped. The dummy variables *carer attendance* (whether parents or caregivers had attended a meeting at the school during the current school year) also became insignificant and were also dropped. The new model was rechecked and found to be valid.

1.4 Model interpretation

The significant variables for modeling the background variables together with their coefficients, standard errors, p-values and confidence intervals are displayed on Table 49.

Table 49: Output of Model 3

Variable	Coefficient	Std Error	P-value	95% Confidence Interval
<i>Test language_English</i>	3.75	0.85	0.001	(1.99 ; 5.52)
<i>Age</i>	-0.58	0.28	0.05	(-1.17 ; 0.0001)
<i>Help homework</i>	0.76	0.42	0.087	(-0.12 ; 1.64)
<i>Hot water</i>	2.27	0.71	0.005	(0.79 ; 3.78)
<i>Carerschool_No</i>	-2.96	0.65	0.001	(-4.32 ; -1.61)
<i>Carerschool_Don't know</i>	-1.96	0.99	0.06	(-4.02 ; 0.09)
<i>Maincarer_father</i>	-2.45	1.35	0.084	(-5.25 ; 0.36)
<i>Maincarer_grandparent</i>	-2.65	0.64	0.001	(-3.97 ; -1.32)
<i>Maincarer_brother</i>	-1.43	1.88	0.35	(-5.36 ; 2.49)
<i>Maincarer_sister</i>	2.35	1.33	0.09	(-0.43 ; 5.13)
<i>Maincarer_relative</i>	-1.25	1.24	0.33	(-3.85 ; 1.35)
<i>Maincarer_non-blood</i>	1.48	1.87	0.44	(-2.42 ; 5.37)
<i>Maincarer_self</i>	-0.2	1.84	0.91	(-4.05 ; 3.64)

The output showed that

- Writing the test in English as opposed to Afrikaans was associated with an increase in achievement gain of 3.75 points, holding all other variables constant.
- An increase in age of 1 year was associated with a decrease in learning of 0.58 points, holding all other variables constant.
- A 1 level increase in the frequency with which an adult provides help with schoolwork at home led to an increase in achievement gain of 0.76 points, holding all other variables constant.
- A learner having hot water at home was associated with an increase in gain of 2.27 points, holding all other variables constant.
- Achievement gain was expected to decrease by 2.96 points (relative to a caregiver that had finished school) when the caregiver had not finished high school, and by 1.96 points when the learner did not know if the caregiver had finished school.
- The effect on achievement gain of who the main caregiver at home is, can be summarised as follows: it appeared as if achievement gain would *decrease* by 2.45 points if a father was the caregiver (relative to a mother as the base category), and by 2.65 points if a grandparent was the caregiver. Achievement gain was expected to *increase* by 2.35 points when a sister as opposed to the mother was the main caregiver.

- No statistical difference in achievement gain was found between a mother being the caregiver (which is the base category) and a brother or another relative or another person (not a blood relative) or nobody (self) being the main caregiver. Although `Maincarer_brother`, `_relative_non-blood`, `_self` are all non-significant variables from the model, they are included on the table because they are part of the same construct or set of dummy variables.

To recap: Two main clusters of variables emerge as significant in relation to achievement gain in the modeling of home background variables – socio-economic variables and ‘out of school’ Opportunity-to-Learn variables. The ‘indirect’ socio-economic variables that emerge are:

- a variable relating to material resources at home – having hot water showed a positive effect;
- a variable relating to family structure – the negative effect of having a low family income (pension) is probably reflected in the negative effect of having a grandparent as the main caregiver as opposed to a mother; and
- a class level variable reflecting the language of instruction – writing the test in English showed a positive effect which, in the Western Cape is associated with socio-economic factors (Seekings, 2001a).

The ‘out of school’ Opportunity-to-Learn variables that emerge are:

- variables relating to cognitive advantages at home - whether the main caregiver had not finished school or not knowing whether the main caregiver had finished school showed a negative effect;
- a variable relating to ‘time on task’ at home - the increased frequency with which an adult provides help with schoolwork at home showed a positive effect;
- variables relating to family structure - the negative effect of the absence of a mother is reflected in the negative effect on gain of having a father, brother, other relative or ‘self’ as the main caregiver; whilst having a non-blood relative or sister as the main caregiver showed a positive effect and is probably associated with the cognitive benefits of having a surrogate mother (and possibly a child-care grant).
- a variable relating possibly to cognitive disadvantage - the older a learner is, the more likely that gain is lower.

In section 2 the significant home background variables will be tested in a model to see whether their effects remain significant when combined with the significant variables for OTL and 'type of pedagogy'.

2. THE COMBINED MODEL

Earlier modeling provided interesting pointers as to which variables or clusters of variables are expected to lead to increases or decreases in gain. The third section of this chapter presents the combined model using all the significant OTL, 'type of pedagogy' and learner background variables from the three previous models to see whether the significant variables from each of the models remain significant. However, first relationships between the significant OTL and 'type of pedagogy' variables were explored.

2.1 Exploring relationships between 'Opportunity to Learn' and 'Type of Pedagogy'

The interplay between the significant variables for OTL and 'type of pedagogy' were explored using boxplots (see figures 30- 35 in Appendix 24). Since the focus of the research is on these two constructs, the individual learner background variables were viewed as control variables and not included in this exploration.

The exploration revealed that the highest levels of *content by cognitive demand* (OTL variable) were associated with weak framing over *selection and sequencing within lessons* (type of pedagogy variables) (figure 30). In other words, where the levels of cognitive demand in lessons required principled as well as procedural mathematics knowledge and learners were engaged to a larger extent with knowledge principles, learners *apparently* had a degree of influence over the micro selection or sequencing of activities, materials, or contents with the teacher adjusted framing in response to learners' abilities or progress. In classrooms where framing over micro selection and sequencing was judged 'barely discernible' (appears very loosely bounded for most learners) or strong (appears very tightly bounded for most learners), it was less likely that teachers were engaging learners with knowledge principles.

Boxplots of the *content by cognitive demand* variable and framing over both *evaluation criteria* variables revealed that average levels of *cognitive demand* appeared to increase slightly with stronger framing over the *evaluation criteria* (figures 31 & 32). This pattern

was clearer for within lesson framing over *the criteria for legitimate realisations of texts* (*evalcrit-post*). Levels of cognitive demand appeared highest where the teacher used error to identify and provide feedback on what was missing from incorrect answers and learners' products or responses were clearly differentiated in terms of how (in what ways) they were unsuccessful or incorrect.

Boxplots did not reveal much of a difference in the average levels of *logabsent* (the number of days learners were absent) and the framing over *micro sequencing/selection* variable (figure 33). Neither did boxplots of the *logabsent* variable and the framing over both *evaluation criteria* variables reveal a difference in the average levels of *logabsent* (figures 34 & 35). Interestingly the strongest pattern was seen for the framing over *the criteria for legitimate realisations of texts* variable whereby average levels of *absenteeism* appeared to decrease slightly as the framing over the criteria is strengthened suggesting a possible association between lower absenteeism levels and explicit feedback on incorrect responses (figure 35).

2.2 Model building

Significant variables from the two constructs, OTL and 'type of pedagogy', and the learner background variables, were combined by running both a forwards and a backwards stepwise regression on all the significant variables from the modeling described in earlier chapters. The variables selected by the stepwise routine were then fitted together with the full set of dummy variables using the *svyreg* command. This resulted in a model run on 830 observations and with a R-squared of 17%.

The model was checked by examining the residuals for normality and for constant variance and was found to be valid (see figures 36-38 in Appendix 25).

2.3 Model interpretation

The significant variables for the combined model are displayed on Table 50 together with their coefficients, standard errors, p-values and confidence intervals. Variables have been ordered by the size of their coefficients, however a larger coefficient does not imply a larger effect.

Table 50: Output of the Combined Model

Variable	Coefficient	Std Error	P-value	95% Confidence Interval
<i>Maincarer_grandparent</i>	-3.01	0.6	0.001	(-4.26 ; -1.76)
<i>Micro Sequencing_1</i>	2.97	0.89	0.004	(1.1 ; 4.83)
<i>Test language_English</i>	2.77	0.72	0.001	(1.26 ; 4.29)
<i>Carerschool_no</i>	-2.6	0.59	0.001	(-3.83 ; -1.36)
<i>Hot water</i>	2.34	0.67	0.002	(0.94 ; 3.73)
<i>Maincarer_non- blood</i>	2.32	0.94	0.023	(0.36 ; 4.28)
<i>Maincarer_sister</i>	2.22	1.24	0.088	(-0.36 ; 4.81)
<i>Cognitive demand</i>	0.49	0.13	0.001	(0.23 ; 0.75)
<i>Age</i>	-0.45	0.19	0.031	(-0.85 ; -0.05)
<i>Logabsent</i>	-0.24	0.12	0.048	(-0.49 ; -0.002)
<i>Maincarer_relative</i>	-1.6	1.24	0.211	(-4.19 ; 0.99)
<i>Maincarer_father</i>	-1.5	1.27	0.253	(-4.16 ; 1.16)
<i>Carerschool_don't know</i>	-1.49	0.91	0.117	(-3.38 ; 0.41)
<i>Maincarer_brother</i>	-1.24	1.36	0.489	(-4.93 ; 2.45)
<i>Micro sequencing_0</i>	1.03	0.93	0.282	(-0.92 ; 2.97)
<i>Maincarer_self</i>	-0.79	1.86	0.676	(-4.69 ; 3.11)

Note: 1. Micro sequencing cannot be interpreted as being a more powerful predictor than cognitive demand because the variables were measured so differently. Cognitive demand is a continuous variable whilst all pedagogical variables are categorical and coefficients can only be interpreted with reference to their reference category.
 2. No statistical significant difference in achievement gain was found between a mother being the caregiver (with base category) and a father, brother or another relative or nobody (self) being the main caregiver. 'Barely discernible' framing over sequencing/selection/pacing (Micro Sequencing 0) was also not found to be statistically significantly different from the reference category (strong framing). Nevertheless the variables are included on the table because they are part of the other sets of dummy variables.

The first observation with regards to OTL and type of pedagogy is that both the framing over evaluation criteria variables was not significant in the combined model. However, the OTL variable, *cognitive demand* remained significant albeit that the positive effect decreased slightly.

The second observation is that the variable, *logabsent* (the number of days learners were absent), remained significant and the negative effect of absenteeism (a content exposure/ 'time on task' variable) remained the same.

Thirdly, the positive effect of weak/responsive *micro sequencing/selection/pacing* (the discursive rules) was quite drastically reduced from 4.82. An increase of 2.97 points was now associated with the teacher adjusting framing over micro sequencing/ selection/pacing in response to learners' level of ability or progress. Although, weak framing over the discursive rules is still associated with an increase in gain as opposed to strong framing, the difference

between indiscernible framing and strong framing became insignificant. In other words, a level or rate apparently very tightly bounded and unrelated to most learners' level of development as opposed to very loosely bounded, no longer shows a significantly greater negative effect on achievement gain.

Fourthly, most of the individual learner background variables' effects were slightly reduced. The positive effect of having hot water had a slight increase while there were several changes with regards to the main caregiver: having a father as the main caregiver was no longer statistically significant from the mother whereas a non-blood relative as the caregiver appeared to be statistically associated with an increase of 2.32 points of achievement gain. The positive effect of living with a non-blood relative could be related to the presence of a surrogate mother. The negative effect of having a grandparent as the main caregiver was also increased.

Interaction between *micro sequencing/selection/pacing* and *content by cognitive demand* was not found to be significant. Interestingly there did appear to be some interaction between *content by cognitive demand* and the *carerschool* (whether or not learners reported that their main caregiver had finished school) dummy variables. That is, the effect of *content by cognitive demand* on gain differed depending on whether the mother or caregiver finished school or not.

On average, the outliers from this model did get a bit smaller but essentially the same cases were found to have the largest residuals. It therefore appears difficult to predict the extreme cases on the basis of these explanatory variables.

To recap: Given that the average gain in achievement for the sample over the academic school year is relatively small (9.96), the effect sizes on gain of predictor variables in the combined model such as weak framing over the discursive rules (2.97) or having a grandparent as a main caregiver (-3.01) are hardly small. Nevertheless, the results of the combined model appear not to confirm the principal assumption of the study by indicating that combinations of aspects of OTL and pedagogy are associated with higher levels of gain. Weak or responsive framing over micro selection, sequencing and pacing is associated with an increase of 2.97 points.

Measures of OTL show that a one unit increase in the cognitive demand rating is associated with an increase in achievement gain of 0.49 points, and, a one unit decrease in 'content exposure' - *logabsent* (a 2.7 day increase in absenteeism) is associated with a decrease in achievement gain of 0.24 points, holding all other measures constant. Although coefficients are not standardised and a larger coefficient does not imply a larger effect and that the variable with the largest coefficient is the most important, the combined model shows that measures of 'type of pedagogy' are also significantly associated with gain.

3. COMPARISON OF RESULTS USING HIERARCHICAL LINEAR MODELING

The main purpose of this study was to investigate the relationship between OTL and 'type of pedagogy' and the mathematics gains of the sample of learners using regression analysis. The regression analysis for this study attempted to account for the fact that each learner has the same value for all (except one) of the OTL and 'type of pedagogy' variables because they generally received the same instruction (Wang, 1998: 145). This was done by, for example, specifying the classes as clusters which informed the model that there is some correlation within clusters, and also by specifying robust standard errors. Nevertheless, in order to compare the results of regression modeling with modeling that distinguishes between individual learner level and class level variables, a secondary analysis using Hierarchical Linear Modeling (HLM) was carried out. Overall HLM allows more flexibility.

Briefly, the HLM models the data at 2 levels: level 1 deals with the within-class data and can be thought of as fitting separate regression models for each class. The predictor variables at level 1 are the variables relating to the individual learners. Note that the level 1 explanatory variables are frequently centred in order to make the interpretation of β_0 more meaningful.

$$Y_{ij} = \beta_{0j} + \beta_{1j}(X_{1i} - \overline{X_1}) + \epsilon_{ij}$$

Level 2 deals with the between-class data and essentially uses the regression coefficients from level 1 as outcome variables. Each of these level 2 equations can be formulated with a random component u (that is, as a free variable that randomly varies across level 2 units) or with this random component set to zero. The predictor variables at level 2 are the classroom

variables. A screenshot showing the formulated model used in HLM can be found in Appendix 26.

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}W_{1j} + u_{1j}$$

The pre-test score was included at level 1 in order to account for the starting level of the pupils when assessing the effect of the predictor variables at both level 1 and level 2. It was identified as a possible confounder and including it allowed the impact of the other variables to be assessed after adjusting for the starting level of the learners.

Variable selection was guided by the results from the regression analysis. The models were then checked for validity by conducting diagnostics on the residuals and carrying out any necessary transformations. Because data manipulation and exploration had been carried out for the regression analysis and the same dataset was essentially used for the HLM analysis and these steps were not repeated.

The first hierarchical linear model fitted was one without any predictor variables at either level 1 or level 2 – this is called a *fully unconditional model* (FUM). This allowed an investigation into whether the response of interest varies across classes and if so to what degree. The Intraclass Correlation Coefficient (ICC) measures the proportion of variance in the response that can be attributed to between groups (or classes). A baseline measure for the amount of variance that occurs both within-classes and between-classes were also taken from this model.

The second stage involved incorporating predictor variables at level 1 and level 2. Comparing these results to the first model provided an indication of how much of the variance in learning had been explained.

The FUM was fitted with a single level 1 variable (the pre-test score) in order to control for the starting level of the learners. This allowed the response variable to be interpreted as a learning gain. The results are displayed below in Table 51.

Table 51: Results of FUM

Fixed effects		
Parameter	Coefficient	P-value
Intercept (β_0)	9.92	0.001
Totalpre (β_1)	0.08	0.001
Random effects		
Parameter	Variance	P-value
Intercept (τ_{00})	12.39	0.001
σ^2	71.76	
Reliability		
Intercept (β_0)	0.818	
ICC		
0.147		

This model showed that the average achievement gain across all classes was approximately 9.92 (and significantly different from zero). The variance in average gain across classes was 12.39 and was found to be highly significantly different from zero.

The Intraclass Correlation Coefficient revealed that 15% of the variance in achievement gain appeared to occur between classes, that is, 15% of this variance can be potentially explained by level 2 predictors. The fully unconditional model potentially explains 15% percent of the average gain across classes. The reliability of almost 82% indicated that the average achievement gain per class was a fairly reliable estimate of the true mean learning per class. In other words, there is some true average learning that a class has and using the sample average is a fairly good estimate of it. (In the *unconditional* model where no variables other than the control variable *totalpre* are included, 85% of the variance lies between individuals.) The full model was fitted by firstly bringing in level 1 variables and then by fitting the between class variables at level 2. The level 1 variables, *logabsent* (individual level data) and *Age*, were initially excluded from the model due to the fact that there were two classes with no data on absenteeism and *Age* was marginally significant (pvalue of 0.08). Furthermore excluding these variables did not make much difference to the other coefficients and the

unexplained level 1 variance. However due to the desire to compare this HLM with the previous analysis, these two variables were left in the model.⁵¹

The variables *age*, *hot water*, *logabsent*, and *total pre-test*⁵² were centred around their grand mean. This means that one interprets β_0 as the average achievement gain for a learner of average age, average access to hot water, average log absenteeism levels, and an average starting level, that also had their mother as the main caregiver and indicated that their mother finished school.

The results of the final model from the HLM are displayed below in Table 52.

Table 52: Results of full model from the HLM

Fixed effects			
<i>Parameter</i>	<i>Coefficient</i>	<i>P-value</i>	<i>95% CI</i>
Intercept (β_0)	-1.2	0.526	(-4.87 ; 2.47)
<i>Cognitive demand</i>	0.46	0.001	(0.24 ; 0.67)
<i>Test language English</i>	2.71	0.003	(1.08 ; 4.35)
<i>Micro sequencing_0</i>	1.42	0.18	(-0.61 ; 3.46)
<i>Micro sequencing_1</i>	2.97	0.002	(1.26 ; 4.69)
<i>Total pre-test</i>	0.07	0.001	(0.04 ; 0.11)
<i>Age</i>	-0.53	0.025	(-0.99 ; -0.07)
<i>Hot water</i>	2.15	0.001	(0.94 ; 3.37)
<i>Logabsent</i>	-0.22	0.072	(-0.47 ; 0.02)
<i>Maincarer father</i>	-1.8	0.084	(-3.84 ; 0.24)
<i>Maincarer grandparent</i>	-2.87	0.001	(-4.39 ; -1.34)
<i>Maincarer brother</i>	-1.5	0.397	(-4.97 ; 1.97)
<i>Maincarer sister</i>	2.08	0.132	(-0.62 ; 4.79)
<i>Maincarer relative</i>	-1.45	0.279	(-4.08 ; 1.17)
<i>Maincarer non-blood</i>	2.27	0.003	(0.8 ; 3.75)
<i>Maincarer self</i>	-0.69	0.773	(-5.35 ; 3.98)
<i>Carerschool_no</i>	2.39	0.002	(-3.85 ; -0.94)
<i>Carerschool_don't know</i>	-1.22	0.099	(-2.67 ; 0.23)
Random effects			
<i>Parameter</i>	<i>Variance</i>	<i>P-value</i>	
Intercept (τ_{00})	3.46	0.001	
σ^2	67.35		
Reliability			
Intercept (β_0)	0.54		

Note: Level 2 variables are indented. Shading indicates where the difference is not significant.

⁵¹ There was 1 learner (#890) with an age of 1 that was changed to 11 for this analysis and was not picked up in the regression analysis.

⁵² β_0 has to be interpreted in terms of all other predictor variables being zero, so even the control variable, pre-test score, has to have sensible interpretation for zero.

The within-class variables (individual level variables) that were found to have significant fixed effects are: age, presence/absence of hot water, log of absenteeism, who the main caregiver was, and whether or not the main caregiver had finished school. The main caregiver variable used 'mother' as the reference category and this was significantly different from 'father', 'grandparent', and 'non-blood'.

The average achievement gain as defined above (average gain for an 'average' learner) in a particular class was found to be significantly associated with the *content by cognitive demand* rating for the class (the higher the demand the higher the average gain); whether the test was written in English (if the test was written in English as opposed to Afrikaans, the higher the average gain); and framing over *micro sequencing/selection/pacing* for that class (weak/responsive framing is associated with higher average gain). The three level 2 variables, *content by cognitive demand*, *test language_English* and *micro sequencing*, explained 72%⁵³ of the variance in the β_0 parameter when all level 1 variables are 0. In other words, after modeling the variables, 72% of the variance between classes has been explained. By implication, 28% of the level 2 variance is still unexplained.

In the FUM the variance in the β_0 parameter is 12.39 without any level 2 variables. In the final model the variance in the β_0 parameter decreases to 3.46. This remaining variance in average gain (that is, what is left over as unexplained after modeling the significant variables) of 3.46 is still highly significant. However, although most gain is at level 1, this does not mean that it is explained. Only 6% of the individual variation has been explained by the level 1 variable (as seen by the value of σ^2 dropping from 71.65 to 67.35)

An interaction between the frequency of speaking English/Afrikaans at home and the language the test was written in was checked for but not found to be significant. Also noteworthy is that the other level 1 effects did not appear to vary across classes though these were not checked methodically due to the focus on the level 2 'type of pedagogy' and 'opportunity to learn' class level variables.

Details of the diagnostics and diagnostic plots are in Appendix 26.

⁵³ This refers to the error term associated with the β_0 equation.

Table 53 summarises the changes to the various coefficients and whether the variables were significant in the HLM.

Table 53: Changes to coefficients in the HLM

Variable	RM Coefficient	HLM coefficient	% change from regression analysis	Significant for RM?	Significant for HLM?
<i>Micro sequencing_1</i>	2.97	2.97	0%	Yes	Yes
<i>Maincarer_grandparent</i>	-3.01	-2.87	5%	Yes	Yes
<i>Test Language_English</i>	2.77	2.71	2%	Yes	Yes
<i>Caverschool_no</i>	-2.6	-2.39	8%	Yes	Yes
<i>Maincarer_non-blood</i>	2.32	2.27	2%	Yes	Yes
<i>Hot water</i>	2.34	2.15	8%	Yes	Yes
<i>Maincarer_sister</i>	2.22	2.08	6%	Yes	No
<i>Maincarer_father</i>	-1.5	-1.8	-20%	No	Yes
<i>Carerschool_don't know</i>	-1.49	-1.22	18%	No	Yes
<i>Age</i>	-0.45	-0.53	-18%	Yes	Yes
<i>Content by cognitive demand</i>	0.49	0.46	6%	Yes	Yes
<i>Logabsent</i>	-0.24	-0.22	8%	Yes	Yes
Not significant for RM/HLM					
<i>Micro sequencing_0</i>	1.03	1.42	-38%	No	No
<i>Maincarer_brother</i>	-1.24	-1.5	-21%	No	No
<i>Maincarer_relative</i>	1.6	1.45	9%	No	No
<i>Maincarer_self</i>	-0.79	-0.69	13%	No	No

The primary result of the HLM is that the actual coefficients for the significant variables did not change much. The biggest changes are that the negative effects of age and of a father being the main caregiver have increased. In comparison to the combined regression model, being older or over-age and, coming from a family where the father (as opposed to the mother) is the main caregiver, are associated with greater decreases in gain in the HLM. In other words, the negative effects of the absence of a mother when a father is the main caregiver, or of being over-age for the grade are strengthened.

The fact that learners 'don't know' whether their main caregiver finished school is associated with a small decrease in gain in the HLM. The 'don't know' category for whether or not the main caregiver finished school became slightly significant as compared with the combined regression model (pvalue reduced from 0.12 to 0.1). The negative effects of a learner not

knowing this information suggests that ‘not knowing’ could be analogous to the caregiver not having finished school and that these two categories could possibly be collapsed.

The only variables where the significance changed in the HLM in comparison to the regression modeling was that the main caregiver category ‘sister’ became insignificant (pvalue of 0.132) when compared to that of ‘mother’ which makes intuitive sense. Table 53 shows that in relation to the *maincarer* variable only the categories ‘grandparent’ and ‘non-blood’ are significant for both the combined regression model and the HLM.

To recap: The results from the regression modeling and the HLM show that results from both forms of modeling are not that different. The following learner background factors remain significant and are associated with an increase in gain in both the combined regression model and the HLM: whether learners wrote the test in English; whether they have hot water at home; and whether their main carer is a non-blood relative. Learner background factors that remain significant and are associated with a decrease in gain are: whether learners are over-age for the grade; whether their main carer is a grandparent; and whether their main caregiver did not finish high school.

The HLM apparently validates earlier findings that achievement gain varies in relation to measures OTL and ‘type of pedagogy’. It confirms the importance of ‘content by cognitive demand’ and ‘content exposure’ for OTL in relation to achievement gain. (Individual level data on absenteeism support the view that more time spent in mathematics classes is related to achievement gain.) Modeling also confirms the importance of responsive framing over micro selection, sequencing and pacing for pedagogy.

Although a multilevel statistical model such as HLM is often considered a more appropriate procedure than linear regression modeling, the comparison of both forms of modeling showed that the results of the two forms of modeling did not differ much when an attempt was made to adjust the normal regression to the data at hand. In this case regression analysis was shown to be a useful tool and the argument against using regression modeling was not upheld. However, as a hidden selection bias cannot be ruled out, estimated coefficients may be biased upwards by unobserved learner characteristics (see footnote 32 in Chapter 4.)

4. RESUME OF THIS CHAPTER

Modeling using only the home background variables for individual learners to discover which if any of the measures are significantly related to achievement gain, showed the following significant associations with increased achievement gain

- 'out of school time on task' and the cognitive advantage of adult participation and engagement in children's schooling through assistance with homework
- writing the test in English as opposed to Afrikaans (a possible socio-economic indicator in the Western Cape)
- having access to material resources such as running hot water at home
- having a sister as the main caregiver as opposed to the mother (this was not significant in the HLM)

The model showed the following significant associations with decreased achievement gain being older or over-age (possibly showing cognitive disadvantage)

- the cognitive disadvantage of coming from a background where the mother or main caregiver has low levels of formal education (defined as not finishing school).
- the absence of a mother - having a father or grandparent as the main caregiver

The results from the fourth regression model to discover which if any of the variables that came out as significant for achievement gain in the three previous models uncover the following interesting relationships with OTL and 'type of pedagogy' variables:

- a one unit increase in the content by cognitive demand rating is associated with an increase in achievement gain of 0.49 points, holding all other measures constant. A 5 unit increase in content by cognitive demand would therefore be associated with a 2.45 point increase in achievement gain.
- higher levels of learner absenteeism are associated with a decrease in achievement gain. A 2.7 day increase in absenteeism is associated with a decrease in gain of 0.24 points, holding all other measures constant. A 7.4 day increase in absenteeism is associated with a 0.48 point decrease in achievement gain suggesting that more time spent in mathematics classes is related to achievement gain.
- weak framing over micro sequencing is associated with an increase in achievement gain of 2.97 points. Earlier data exploration revealed that the three variables within lesson selection, sequencing and pacing had a strong association with each other and tended to have the same pattern. that is, the same types of framing were generally

seen for these variables so that learners with strong framing over micro selection tended to have strong framing of micro sequencing. Furthermore, because model building using only 'type of pedagogy' variables showed multi-colinearity to be of concern only one of these variables was used in the models. The finding for the combined model is that achievement gain is higher where teachers weaken framing over the selection, sequencing and pacing of content, materials and tasks in their lessons in ways that are responsive to learners' capabilities, level and rate of progress.

Relationships with most of the learner background variables' effects remained significant except that a father being the main caregiver was not statistically significant in the combined model.

HLM modeling to compare results using a multilevel statistical model showed that the coefficients for the significant variables did not change much when individual level data was modelled within class and class level data between-classes. Most of the effects or influences held up when data was analysed at both levels suggesting that regression modeling remains a useful tool in this context.

The results of RM and HLM disconfirm the principal assumption of the study by indicating that, compared to OTL, 'type of pedagogy' is associated with higher levels of gain. However, data exploration outlined in Chapter 5 indicated that OTL may 'work' more slowly over time and that the across grade effects of OTL need to be considered in a model which assesses cumulative effects of curricular pacing on achievement over a much longer period of time. The significance of this is considered more fully in Chapter 8 where I return to the main hypothesis and consider whether measures of OTL are more important for policy than measures of pedagogy in relation to overall achievement status. Clearly investigating factors involved in learner achievement is highly complex.

Chapter 8

CONCLUSIONS AND IMPLICATIONS

The aim of this research has been to establish:

- a) the effects of measures of two focal constructs on grade 6 mathematics achievement, namely
 - i) 'Opportunity-to-Learn';
 - ii) 'Type of pedagogy';
- b) whether either of the two constructs have significantly greater effects on achievement; and
- c) which might therefore be more worthy policy variables to pursue in South Africa.

This chapter concludes the study by providing an overview of the main findings and then discussing them in relation to the research questions, the analytical framework outlined in Chapter 3 and the main hypothesis. In the second part of the chapter, I discuss the implications for policy and, in section 3 I derive some recommendations for policy. Section 4 of the chapter ends with a consideration of the research model used and the main methodological lessons learnt.

1. THE MAIN FINDINGS

Effect size

Rowan, Correnti & Miller (2002: 24-25) submit that research models such as the one used in this study which focus on factors that influence achievement 'present analytic situations in which the decks are stacked against finding large effect sizes' because they investigate naturally occurring variations in the variables of interest. They aver that one should not expect variables to explain 'differences of magnitude' because few if any classrooms are likely to present optimal conditions for the variables of interest (*ibid*: 22).

Indeed, at first glance it might appear that none of the statistical findings in this study indicate significant effects. However, when one takes into account that the average gain in achievement for the sample over the academic school year is relatively small (9.96), the effect sizes on gain of some of the more significant variables are hardly small. Furthermore,

as the following review shows, the statistical modeling and data exploration provide a number of important insights into other possible relations and associations between individual learner background factors, pedagogic practices, opportunity-to-learn and achievement scores for the particular sample of low SES learners. The review includes findings

- using variables from the two constructs, OTL and ‘type of pedagogy’, and the learner background variables in three separate models;
- from the combined model using all significant variables from the three earlier models to discover which remained significantly related to achievement gain;
- from data exploration focusing on the relationship between overall achievement status and across grade/s framing over pacing;
- from the comparison of the results of the regression modeling with the results of the HLM.

1.1 Review of main findings

Statistical modeling using the **combined significant variables** indicates the following:

- When learners have the same starting point as controlled for through the pre-test score, it is teachers’ ability to engage learners with mathematics at higher levels of *content by cognitive demand*, that is, to a larger extent with principled knowledge, that promotes *achievement gain* across an academic school year;
- *Achievement gain* across a single school year also increases when teachers weaken framing over *micro selection*, *sequencing* and *pacing* of contents, materials and activities responsively within their lessons;
- The highest levels of *content by cognitive demand* (an OTL variable) are associated with weak framing over *micro selection*, *sequencing* and *pacing within lessons* (‘type of pedagogy’ variables). Levels of cognitive demand are highest where teachers weaken framing within lessons over these elements of the discursive rules in ways that are responsive to learners’ ability or progress;
- The average levels of *content by cognitive demand* also appear to increase slightly with stronger framing over the *evaluation criteria*, particularly where the criteria for legitimate realisation of texts for evaluation are made explicit within lessons. Where the cognitive demand is highest, pedagogical practices tend to be characterised both

by strong framing over the evaluative rules and weak or responsive framing over the discursive rules for selection, sequencing and pacing;

- Less time on task measured as higher levels of *learner absenteeism* (an OTL variable) is associated with a decrease in *learning gain*. Individual level data thus appear to support the view that *content exposure* defined as time spent in mathematics classes is related to achievement gain;
- The average level of *absenteeism* appears to decrease slightly as the framing over the evaluative realisation rules strengthens;
- *Individual learner background variables* still account for some of the largest variances in *achievement gain* indicating that at least some of the differences in achievement gain are related to differences in background factors amongst the sample;
- There appears to be some interaction between *content by cognitive demand* in the classroom and whether or not learners reported that their main caregiver had finished school.

Modeling of only the pedagogy variables shows that

- when the relation between *achievement gain* and *pedagogic practices as a whole* is considered, no association is evident. Neither the overall strength over framing and classification for the instructional nor the regulative contexts, both separately and combined, are highly correlated with achievement gain;
- explicit *evaluation criteria* contribute to *gain*, particularly strong framing over the criteria for legitimate realisations of texts for evaluation. Modeling using only the pedagogy variables shows that gain increases where teachers give direct expositions, and use error or what is 'missing' from learners' responses to deal with misconceptions and difficulties and provide explicit feedback on incorrect answers;
- a greater *decrease* in *achievement gain* is evident where framing over the *evaluation criteria* in lessons is *implicit* than when framing is 'barely discernible'. In other words, when teachers use exploration and discussion to draw out and elaborate on the evaluation criteria, the *decrease* in gain is greater when the teacher provides hints and cues to indicate which responses are more valid than when the teacher treats all learners' products as equally valuable, and evaluation focuses neither on what is 'present' nor on what is 'missing';

- weak framing over the *criteria for legitimate realisation of texts for evaluation* as opposed to the weak framing over the *evaluative recognition rules* is associated with a greater decrease in gain. Explicit feedback on incorrect answers seems more important than explicit expositions of worked solutions and detailed demonstrations of procedures to follow;
- the degree to which the criteria for evaluating learners' texts are implicit or explicit is associated with framing over *micro sequencing, selection, pacing* within lessons. Strong *framing over the criteria for legitimate realisation of texts for evaluation* is associated with weak/responsive framing over micro selection/sequencing/pacing. 'Barely discernible' framing over the criteria for legitimate realisations of texts for evaluation is associated with either 'barely discernible' framing over micro selection/sequencing/pacing (for example, where the pace set in lessons appeared unconstrained by curriculum expectations) or with strong framing (where the pace, for example, appeared very tightly bounded for most learners);
- a strong association exists between within *micro selection/sequencing/pacing* and classification of the *hierarchical relations between learners*. 'Barely discernible' framing (F0) or strong framing (F2) over *micro selection* is associated with 'barely discernible' classification (C0) of hierarchical relations between learners.

Data exploration focusing on the relationship between *curricular pacing* and *pre- and post-test scores* showed that

- when the relationship between *pre-test scores* and *coverage of grade 5 topics* was investigated to see whether coverage of grade 5 topics affected the pre-test score or starting level of the learners, a positive relationship was suggested. A scatterplot suggested a quadratic relationship in that a slight pattern with higher average pre-test scores tended to be associated with higher grade 5 topic coverage up to a certain point. The pre-test score was then regressed on the number of grade 5 topics, resulting in grade 5 topic coverage being highly significant. It appears that greater coverage of topics in earlier grades could prepare learners better for subsequent grades;
- when the relationship between *post-test scores* and *coverage of topics in grade 6* was investigated to see whether *content coverage* in grade 6 affected the post-test score or learners' end level, the correlation of the post-test score with the number of grade 6

topics covered suggested a positive relationship. When the post-test score variable was then regressed on grade 6 content coverage, this signalled evidence of a possible association between greater coverage within the grade (up to a certain point) and higher test scores;

- there was an association between *content exposure* (time on task/opportunities to practise), measured as the number of pages in workbooks, *curricular coherence* (across grade framing over *macro sequencing*) and *content coverage* (across grade framing over *macro pacing*). Higher *curriculum coherence* is associated with higher *content coverage*. *Content exposure* measured as the number of pages in the workbooks correlates with *content coverage* measured as the number of Intermediate Phase topics covered in grade 6.

1.2 Relating findings to the research questions

The following discussion relates the above findings more directly to the questions the study hoped to answer, which are:

- i) whether OTL or 'type of pedagogy' overall has more influence on achievement;
- ii) whether combinations of aspects of OTL and pedagogy (separately and together) have more influence on achievement;
- iii) which family background factors interact with OTL/pedagogy in relation to achievement.

The findings are discussed first in relation to learners' home background and then in relation to the two focal constructs

- 'Type of pedagogy'; and
- 'Opportunity-to-Learn'

Home background

The cluster of 'indirect' socio-economic status variables that emerge as significant in relation to achievement gain in the statistical modeling of home background variables are as follows:

- having hot water at home, a variable relating to material resources, showed a positive effect;
- having a grandparent as the main caregiver as opposed to a mother, a variable associated with a low income, showed a negative effect; and

- a class level variable reflecting the language of instruction – writing the test in English - showed a positive effect which, in the Western Cape, might be associated with socio-economic factors.

The cluster of ‘family-background’ Opportunity-to-Learn variables (Floden: 2002) that emerge are as follows:

- whether the main caregiver had not finished school, or a learner not knowing whether the main caregiver had finished school, variables both relating to cognitive disadvantages at home, showed a negative effect;
- the increased frequency with which an adult provides help with schoolwork at home, a variable relating to ‘time on task’ at home, showed a positive effect;
- having a father as the main caregiver showed a negative effect on gain reflecting the negative effect of the absence of a mother;
- having a sister or non-blood relative as the main caregiver showed a positive effect which could be associated with the presence of a surrogate mother as well as a child-care grant;
- the older a learner is, a variable relating to cognitive disadvantage, the more likely that gain is lower.

As discussed in Chapter 4, in South Africa Anderson *et al.* (2001) and Case & Deaton (1999) similarly found that differences in achievement are related to differences in socio-economic background. Simkins (cited in Taylor *et al.*, 2003) and Howie (2002) found an association between language and achievement. Interestingly in this study no association was found between the language most often spoken at home and the language in which the test was written – suggesting that, for this Western Cape sample, socio-economic status is a more significant factor. Howie & Pietersen (nd in Seekings, 2001a: 109) using available data for grade 12 from the 1995 and 1999 TIMSS found age was a factor in that ‘older students performed worse than younger ones’. Anderson *et al.* (2001), Case & Deaton (1999), and Jubber (1998) all established ‘a strong, positive relationship between mother’s schooling and the schooling of their children’ (Seekings, 2001a: 105). Anderson *et al.* (2001) found that family structure relating to who the main caregiver is at home has an effect on achievement.

To recap: Alongside other South African studies findings confirm the notion that home background is a big influence and that other inequalities outside the classroom are affecting gain differences. Two main clusters of home background variables emerge as significant in relation to achievement gain in the statistical modeling – SES variables and ‘out of school’ OTL variables. However, as discussed below, findings relating to ‘type of pedagogy’ and OTL also confirm the view that schools and teachers are at least partly responsible for achievement gain (Kravis, Heston & Summers, 1982: 156, Reynolds & Creemers, 1990; Stevenson, Lee & Schweingruber, 1999; Heneveld & Craig, 1996 in Marshall & White, 2001; Van der Berg & Berger, 2002; Floden, 2003; Taylor *et al.*, 2003).

‘Type of pedagogy’

Data from the study confirm that ‘*type of pedagogy*’ does not produce significant effects for this particular sample of learners and their teachers. Findings appear to support the views of researchers such as Rosenshine & Berliner (1978) and Maja (1998) that, as far as achievement gain is concerned, *overall pedagogical style* does not matter. Rather, modeling using the elements separately to test the relative influence of each element of pedagogy indicates that certain features of pedagogical practice are more important than others in relation to achievement gain. What can be inferred from this study is that, in line with research conducted by Morais & Neves (2001) in Portugal certain elements of invisible and visible pedagogy should be ‘mixed.’ In this study, elements of the instructional discourse emerge as significant for achievement gain in the statistical modeling.

On the one hand, findings from the combined model support the notion that a teacher’s level of subject knowledge or ‘proficiency of the knowledge to be taught’ (Reimers, 1993; Taylor & Vinjevold, 1999b; Morais & Pires, 2002; Crouch & Mabogoane, 2001) affects growth in achievement over the particular period of time when learners have access to that teacher. Findings indicate that it is higher levels of *content by cognitive demand*, a variable that reflects teachers’ mathematical proficiency and understanding of the underlying knowledge principles (an OTL variable), that promotes *gain*. On the other hand, the findings suggest that mathematics gain improves where learners influence decisions around the *discursive rules* of selection, sequencing and pacing (a ‘type of pedagogy’ variable) through the teacher adjusting *micro selection*, *sequencing* and *pacing* in their lessons in ways that are responsive to the average learners’ level of ability and progress.

Findings appear to support the view that there may be, as is suggested in Morais & Pires (2002), interdependence between teachers' ability to engage learners to a larger extent with principled knowledge (teachers' own understanding of the underlying mathematics principles) and their pedagogical ability to weaken framing over the micro selection and sequencing responsively but in ways that also go beyond learners' current level – through the creation of Vygotsky's (1987 in Newman & Holzman, 1993) 'Zone of Proximal Development' or ZPD. What can be inferred from the above analysis is that it is the teacher's competence and professional expertise that is more important than overall pedagogical style in relation to learning gain.

There is other evidence about what constitute more or less effective teaching practices for this sample of low SES learners and their teachers:

- Modeling of only the 'type of pedagogy' variables appears to confirm the view that strong framing over *evaluation criteria* improves *achievement gain* for the sample, particularly teachers' use of error to provide feedback on incorrect answers (strong framing over the realisation rules). In more developed country contexts, Morais & Neves (2001); Lubienski (2001); Morais & Pires (2002) likewise suggest that explicit evaluation criteria is associated with improved achievement outcomes for working class learners. However, in this study of low SES learners in the Cape Peninsula, the effect of strong framing over the evaluation criteria is no longer significant in the combined model using all the significant variables from previous models. On the other hand, the effect of higher levels of *content by cognitive demand* (learner engagement with principled and not just procedural knowledge) on *gain* remains significant for the combined model. This suggests that, for most of the sample, *the cognitive level of the teacher's expositions and feedback on error* is the discriminating factor in relation to *achievement gain*. Data indicate that what makes the difference in relation to gain for this sample of learners and their teachers is the teacher's ability to engage learners to a larger extent with principled and not just procedural knowledge when giving expositions and when dealing with misconceptions or giving feedback on incorrect answers.
- Important in relation to South Africa's current pedagogical policy, is the trend that the effect of weak framing over *evaluation criteria* (F1) is worse than 'barely discernible'

framing (F0). This implies that, not only did learners who were exposed to implicit evaluation criteria not recognise (or miss) the evaluative hints, clues and cues provided by their teachers, they appear to have misconstrued them or been confused by them. The finding appears to confirm work done in the USA by Lubienski (2004) who found that her own efforts to use contextualised situations to draw out knowledge principles through exploration and discussion tended to confuse working class learners about what they were supposed to be learning. Low SES learners struggled to pick up on the implicit hints and clues she provided.

- Findings also suggest that issues of *evaluation* are associated with issues of micro selection, sequencing and pacing. *Responsive/weak micro selection, sequencing and pacing* (for example, where learners appear to influence selection in lessons in that the teacher adjusts content or tasks in response to learners) appears to be related to evaluation practices. Data suggest that, by ascertaining learner error, teachers are better able to adjust the selection, order and pacing of contents, tasks or material according to the average learners' level of capability and progress (for example, by revisiting or reviewing work if necessary or leaving out items that most learners have already mastered). Of interest in relation to this is that 47% of the sample experienced a pedagogical approach where the pace set was apparently very loosely bounded, whilst 16% experienced a form of pedagogy where framing over pacing appeared to be very tightly bounded.
- A strong association between within lesson framing over *micro selection, sequencing and pacing* and weak classification of the *hierarchical relations between learners* implies that collectivising learners' pedagogical identities is associated with 'barely discernible' framing over *micro selection* where the content or tasks set appear too easy for most learners and at too low a level for grade 6. Descriptive data on pedagogical practices shows that 39% of the sample's pedagogical identities appeared to be collectivised or homogenised to the extent that their individual status as maths learners was virtually indistinguishable. Data confirm the view that, whilst mathematics teachers should be able to evaluate the whole class at once to gauge the average level of ability and rate of progress during lessons, teachers' knowledge of individual learner's ability and progress plays an important role in this. This

emphasises the importance of teachers assessing or marking each learner's work and confirms the notion that individual evaluation is crucial for the specialisation of learners' consciousnesses as is suggested in the South African study by Ensor *et al.* (2002). Although strong classification of hierarchical relations between learners is associated with responsive framing over *micro selection/ sequencing/ pacing*, the inference is that individual differentiation at the instructional level is important.

- In Chapter 3, I discussed Morais & Neves' (2001) findings that the combination of weakened framing at the level of the hierarchical rules together with explicit evaluation criteria improved achievement outcomes. In contrast to their findings, in this study no elements of the *regulative discourse* emerge in the modeling as predictor variables for gain. However, the communication relations between the teacher and learners in the analysis were very similar for most learners. In most cases, teacher-learner communication relations were closed and learners participated in teacher-learners interactions only when invited to do so through the teachers' questioning. This could explain why this element of pedagogic practice does not emerge in the modeling as a predictor variable for achievement gain.

To recap: Elements of the instructional discourse within lessons emerge as significant for achievement gain in the statistical modeling. Modeling of all significant variables shows that the biggest gains are produced by weak framing over the discursive rules within lessons. In other words, gain increases where framing over micro selection, sequencing and pacing are responsive to learners' levels of ability and progress. Modeling using only the pedagogy variables indicated that decreases in gains are associated with lack of clarity over the evaluative rules, indicating that, for this sample of learners and their teachers, weak framing (F1) over the evaluative rules appears unable to specialise text.

'Opportunity to Learn'

The positive effect of higher levels of *content by cognitive demand* on *achievement gain* remains significant for the combined model. Of interest is that the positive effect of *content by cognitive demand* on gain differed depending on whether the mother or caregiver had finished school or not.

Individual level data on *absenteeism* support the view that more time spent in mathematics classes is related to *achievement gain*. As Wang (1998: 150) observes ‘considering that attendance rate only measures the physical presence and absence of the students, this finding points to the importance of attending the class when instruction is delivered. Simply by attending class, students have a learning opportunity.’ Of interest here is that data also suggest a possible association between lower absenteeism levels and explicit feedback on incorrect responses in lessons.

However, the most unanticipated and interesting insights on OTL are provided through the data exploration focusing on the relationship between the OTL variables *content coverage* and *curricular pacing* and *achievement scores* in the pre- and post-test (achievement at a point in time). Whilst teacher competence appears to be a most important factor for achievement gain over one school year, greater *content coverage* across each grade and adjacent grades (*macro pacing*) could, up to a certain point, be associated with higher overall *achievement scores* (higher pre- and post-test scores). In other words, the effects of the prior opportunities to learn may be represented in the achievement measures (Floden, 2003: 250). Although no causal conclusions can be drawn, *curricular pacing* emerges as a potential variable, not for achievement gain as expected, but for overall *achievement status*. Data exploration suggest that greater across grade content coverage (inter-grade pacing over a number of school years) could be associated with higher mathematics scores rather than increases in gain across a single school year.

The inference is that higher levels of curricular pacing have a degree of influence over preventing learner under-preparedness and under-achievement or a cumulative deficit in mathematics achievement over each school Phase. Curricular pacing could have an exponential function which plays a role in overall academic growth. This potentially advances the view that learners who experience consistent curricular coverage over the years show gains in achievement accumulated over time whilst learners who experience consistently low coverage or weak framing over macro pacing over many school years end up with lower cumulative achievement scores overall (Rowan, Correnti, & Miller, 2002: 9; Smith, Smith & Bryk, 1998).

Furthermore, data exploration shows that good logical across grade sequencing (curricular coherence) and greater content exposure measured as the number of pages in workbooks -

that is more time spent overall on mathematics work - are related to greater coverage. Whilst other research has shown that the amount of time spent on academic tasks in class correlates highly with achievement (Lee, 1982; Fischer *et al.*, 1980; Stallings: 1975), this study signals that more *content exposure* and good *curricular coherence* contribute towards increases in *curricular pacing*. In other words, more 'time on task' and 'opportunities to practise' and good logical macro sequencing can lead to more content coverage and an increase in across grade pacing. Variations in time spent overall on mathematics and variations in the internal coherence of the sequencing of curriculum content partly explain why content coverage differs. The suggestion is that the curricular pacing is enhanced

- by good logical sequencing of mathematics content across grades (curricular sequencing/macro sequencing)
- when learning time is maximised and more time is spent on mathematics (content exposure).

On one level this finding contrasts with Reimers' (1993) study in Pakistan that found that in a 'weak system' 'teaching time by itself is a poor predictor of student achievement' (ibid: 7). This study indicates that more time devoted to teaching mathematics is possibly linked to achievement through better content coverage and curricular pacing. On another level, the finding is in line with Reimer's and Carroll's (1963) assertions about the quality of learners' exposure to instructional content in that they suggest that, if curricular content is not presented to learners in ways that are logically and sequentially connected, learners will need more time to learn (see 1.1.2 in Chapter 2).

To recap: Statistical modeling shows that an increase in the level of content by cognitive demand is associated with an increase in achievement gain and, that a decrease in content exposure is associated with a decrease in achievement gain. More importantly, data exploration indicates that, in relation to closing or, at least, substantially narrowing the huge gap in achievement outcomes, curricular pacing across time (inter-grade pacing over a number of school years) may be a more significant measure in relation to overall achievement status than gain. The findings and data exploration appear to support the notion that the issue 'is not that instruction be mindlessly speeded up or that more is necessarily better', rather it is that learners 'should experience a sequence of instruction that exposes them (to mathematics knowledge) in a systematic and developmentally challenging fashion' (Smith, Smith & Bryk, 1998: 12 – my addition).

In section 1.3, I summarise the implications of the above findings in relation to the analytical model used in the study and the main research hypothesis.

1.3 Implications in terms of the analytical model and the research hypothesis

Table 6 in section 5.3 of Chapter 3 summarised the analytical model constructed for the study. The table presents the Opportunity-to-Learn variables and ‘type of pedagogy’ variables in terms of Bernstein’s language of description. The purpose of the model was to provide a framework for separating micro level practices evident within lessons from the curriculum made available to learners at the macro level across the academic school year/s. The framework rendered the OTL dimension of pedagogical discourse sufficiently conceptually independent from ‘type of pedagogy’ for the two dimensions of pedagogical discourse to be operationalised for the empirical study. However, as stated earlier, the model also ties the two constructs together, illustrating that the OTL dimensions pertain to framing over the discursive rules but foregrounds the instructional aspect of framing over pacing and sequencing. ‘Type of pedagogy’ foregrounds the micro code or the regulative aspects of framing over the discursive rules in the classroom.

Table 54 below summarises only those dimensions of OTL and elements of pedagogy potentially linked to the mathematics achievement of the low SES learners. The table provides the framing values that seem important for improving achievement.

Table 54: Dimensions of OTL and elements of pedagogy potentially linked to mathematics achievement and their framing values

OPPORTUNITY-TO-LEARN (MACRO LEVEL)			'TYPE OF PEDAGOGY' (MICRO LEVEL)	
INSTRUCTIONAL CONTEXT				
DISCURSIVE RULES (FRAMING)				
OFL dimensions	Bernstein's language of description	Framing value	Elements of pedagogy	Framing value
			Within lesson framing over selection/micro selection	F- Responsive framing.
Curriculum coherence	Across grade framing over sequencing/macro sequencing	F+ Strong	Within lesson framing over sequencing/micro sequencing	F- Responsive framing
Content coverage by cognitive demand; Curriculum pacing; Content exposure	Across grade/s framing over pacing/macro pacing	F+ Strong	Within lesson framing over pacing/micro pacing	F- Responsive framing.
			Framing over the evaluation criteria	F+ Strong framing

The model outlined in the summary on Table 54 supports the importance of the instructional context for enhanced achievement for low SES learners. It advances the importance of framing over the discursive rules, specifically:

- Weak/responsive framing over selection/ sequencing/pacing at the micro level of the classroom;
- Strong framing over selection/sequencing/pacing at the macro level of across school year/s;
- Strong framing over the evaluation criteria, particularly the criteria for legitimate realisations of texts for evaluation

In answer to the main research hypothesis: 'Does OIL in schools serving low SES communities influence achievement outcomes more than pedagogy?' – the study's findings do not confirm the primary assumption of this study that, in relation to achievement gain, OIL is more important than 'type of pedagogy'. Rather, the results of findings show that OIL and pedagogy variables both significantly effect achievement. Furthermore, for the low SES learners in the study, the OIL and pedagogical variables that emerge as significant are all in the instructional context. No elements of the regulative context feature as salient in relation to improved achievement.

There is, however, a strong association between framing over *micro selection* and classification of *hierarchical relations between learners*. 'Barely discernible' framing (F0) or strong framing (F2) over *micro selection* is associated with 'barely discernible' classification (C0) of hierarchical relations between learners. This implies that selection of content, tasks or materials that is insensitive to learners' levels of development may be associated with communalising learners' pedagogical identities. Individual differentiation at the instructional level appears to be important for specializing individual learners' voices.

The pedagogical variables that are generally considered important and which are emphasised in South Africa do not emerge as significant in the study. For example, the promotion of collaborative group work endorses weak framing over communication relations between learners but this does not emerge as significant in relation to achievement. The framing values of those pedagogical variables that do emerge as significant are different from the values advocated in South African curriculum policy documents. For example, promoting the use of 'real world' problem solving as a pedagogical tool for inducting learners into school knowledge rather

direct expositions of procedures to be followed entails weakening framing over the criteria for evaluation. Findings indicate that explicit evaluation criteria are associated with gains.

Then again, not all four dimensions of the OTL construct that the international literature led me to expect to be associated with achievement outcomes appear to be directly related to achievement. Rather some dimensions, namely curriculum coherence and aspects of content exposure, apparently augment dimensions potentially associated with achievement, namely content coverage by cognitive demand and curriculum pacing.

The model that emerges from the summary on Table 54 confirms the notion of a mixed model of pedagogy that is taking shape 'with greater detail and nuance' through research 'across the continents' (Muller, 2004b:6). However, the significance of this study is that, by inserting OTL into the Bernstein schema, which in terms of Bernstein's definition relate to *macro* level pacing and sequencing, the study advances on the notion of a mixed model by making visible the specialisation of learners' identities through *macro pacing and sequencing* of curricular content.

In the following section I derive some implications from the above for policy.

2. POLICY IMPLICATIONS

Findings and data exploration seem to at least partially explain variation in achievement for the sample. They suggest that mathematics achievement for the sample is associated both with teacher's 'professional expertise' (teacher effects) and learners' 'curricular opportunities' (curricular effects) (Rowan, Correnti & Miller, 2002: 1).

As stated earlier in this thesis, school effectiveness research such as that done in South Africa by Crouch & Mobogoane (2001) generally use static proxy measures of teachers' subject expertise such as qualifications to show that teacher competence is related to achievement. Smaller-scale case studies have also probed on the link between teachers' subject knowledge and learner achievement and claimed a correlation between teacher knowledge and achievement outcomes (see, for example Webb *et al.* in Taylor & Vinjevoold, 1999b). What the present study does is provide more specific information on how teacher competence actually 'works' in the classroom to make a difference in relation to achievement.

The findings make it possible to begin to formulate in pedagogical terms what 'teacher competence' means in the South African context. They make it possible to begin to develop a more explicit model of what teacher effectiveness in classrooms with predominantly low SES learners looks like more broadly. The study provides insights into how teacher competence potentially relates to a combination of content knowledge and ability to mobilise this knowledge pedagogically to ensure thorough coverage of the grade level curriculum. The model that is emerging is one where teacher quality or competence is defined as a combination of teacher's

- a) mathematical proficiency and content knowledge, in particular, understanding and knowledge of underlying mathematics principles and ability to engage learners with principled and not just procedural knowledge,
- b) 'pedagogical content knowledge' where teaching quality is defined as teacher's knowledge of individual learners' ability and progress, capacity to be adaptive to the average learners' level of ability and progress and to deal with misconceptions and difficulties (Shulman, 1987)
- c) understanding and delivery of the grade level mathematics curriculum as a coherent entity underpinned by internal disciplinary principles where the relationships between the parts hold the curriculum together rather than simply delivering the curriculum as a series of fragmented and disconnected components within each grade.

The statistical analysis and exploration points to evidence that, whilst variance in *achievement gains* across one school year lies partly in differences in teacher effects over the particular period of time when learners have access to that teacher, variance in overall achievement scores may lie partly in accumulated curricular effects over many years.

To recap: Indications are that learners' overall achievement status may reflect learners' cumulative OTL over their entire learning careers rather than just over one school year. The implication is that overall achievement status may not be 'fixed' to any one teacher or any one academic school year but to curricular pacing across each phase of learning.

At a policy level this is important because, as Rowan, Correnti & Miller (2002: 9) observe, teachers usually only have learners in their classrooms for a single year and, in most schools learners have access to different teachers over their learning careers. By implication, whilst developing teacher expertise and improving teacher effectiveness more broadly should be

seen as an important longer-term goal for reducing inequality in achievement gain, if the intention in South Africa is to reduce present inequalities in accessing high status mathematics knowledge, we need to be realistic about capacity.

Descriptive data from this study showed evidence of slow within-grade pacing or macro pacing across grade 5 and 6. Data showed that grade 5 and 6 learners spent more time on mathematics contents they were expected to have covered in earlier grades than they did on contents at the level expected for both grades. This study's findings suggest that we need to consider whether a quicker and more achievable way of raising achievement in our current context in the short-term might be that of focusing on trying to ensure that all learners 'experience a sequence of instruction that exposes them' to the mathematics curriculum 'in a systematic and developmentally challenging fashion' over their whole learning career (Smith, Smith & Bryk, 1998: 12).

What the descriptive analysis and statistical exploration of the OTL data in the four districts of the Cape Peninsula suggests is that, whilst the RNCS for numeracy and mathematics have potential for improving the quality of curricular pacing at the level of implementation, their potential for reducing inequality in achievement scores might depend crucially on additional guidance and support to schools. As Gamoran (2000) points out;

If standard-setting raises the bar for the quality of students' experiences in schools, and not just their performance on tests, then it holds some promise for reducing inequality as well as enhancing levels of learning. If standards mean nothing more than standardized tests on a wider scale, they may serve to highlight inequalities that already exist, but they will do little to ameliorate the problem. The challenge confronting standards initiatives is not just that achievement is too low and too unequal, but that learning opportunities that produce achievement are unequal (pages 93-94).

3. POLICY RECOMMENDATIONS

With the above in mind the following recommendations are derived for policy in relation to enhancing the curricular opportunities made available to low SES learners. Findings suggest

that the South African context, assessment standards alone may not be enough.⁵⁴ Successful implementation of policy inputs such as the recent curriculum changes may require better

- signalling
- co-ordination; and
- evaluation/assessment

3.1 Recommendation in terms of signalling

A potential limitation on the generalisability of this study's findings is the fact that mathematics teachers now have far better signalling of expected content through the RNCS. Nevertheless, the study revealed evidence of slow curricular pacing, weak curricular attention for some Learning Outcomes, and that learners are studying topics below grade level expectations. Indications are that more guidance may be required in ensuring **curriculum coverage and pacing across each grade** at least for subjects with strong verticality of knowledge structure such as mathematics and natural sciences. For example, the reviewed mathematics curriculum documents provide little in the way of guidance in relation to **content emphasis**⁵⁵ but descriptive data from the study suggests that teachers may need greater signalling as to how much time should be allocated to work to the topics and sub-topics to be covered.

Recommendations of this study are that policy documents such as **curriculum frameworks and guidelines**:

- provide teachers and schools with a much clearer and more accessible overall mental picture of the entire trajectory of each learning phase (across grade framing over pacing).
- provide teachers with more in the way of guidance in relation to the pace they should maintain in order to cover the grade level expectations. Frameworks and guidelines need to assist them in deciding how much work needs to be covered over a specific time frame (across grade framing over pacing) and how many periods they should ideally devote to certain topics and sub-topics (content emphasis).

⁵⁴ As stated in Chapter 1, a key limitation of this study is that the findings might not hold for subjects such as art which draw on more horizontal knowledge structures (Muller, 2004a).

⁵⁵ A further limitation of the study is that I used the judgement of only 3 expert grade 6 mathematics teachers regarding the amount of time teachers should ideally devote to sub-topics.

Such **content pacing and progression signals** would be of particular value to inexperienced and less qualified teachers.

3.2 Recommendation in terms of co-ordination

The study revealed evidence of poor inter-grade co-ordination. Not only are learners studying topics below the grade level expectations and experiencing omissions in curricular topics, they are also experiencing unnecessary repetitions. There is evidence that learners are being exposed to similar content across grades. Descriptive data from the study showed that, for the majority of learners, the curriculum is experienced as a series of dislocated and fragmented components. The order in which topics are covered mostly do not reflect sequential development. Statistical exploration showed that good logical sequencing of curriculum content is associated with greater content coverage.

Indications are that much more direct support may be required in ensuring **curricular coherence** (across grade framing over sequencing) and with co-ordinating content coverage or **curricular pacing across grades**. Findings suggest that teachers and schools may need more direct support with ensuring progression throughout learners' learning careers.

A **recommendation** of this study is for support directed at **co-ordinating work schemes and learning programmes** across grades and phases. This could be done through

- the provision of learning programmes and schemes of work that demonstrate forms of across grade pacing. Such programmes and schemes would need to promote content coverage whilst making it possible for teachers to be responsive to learners levels of progress (weak selection, sequencing and pacing) as a key issue in many classrooms is closing the gap between the grade level expectations and the existing knowledge base of learners;
- good well-structured textbooks that help bring coherence into teachers' year plans as well as the provision of guidelines for schools for choosing high-quality textbooks;
- developing and using the expertise of Learning Area specialists or heads of department within schools to ensure and monitor progression (across grade content complexity and across grade developmental complexity);

- direct assistance to schools and teachers with planning work schedules and learning programmes across grades and school phases through interventions and school level support from Education Department subject advisers and outside agencies.

3.3 Recommendation in terms of evaluation or assessment

From a methodological point of view the study's findings suggest that individual differentiation at the instructional level is important for specializing individual learner's voices. Findings suggest that pre-test results are poor because of poor inter-grade signalling through assessment practices. The poor pre-test results in the study point to the importance of the previous teacher's systematic evaluation of what individual learners know and of where they are in relation to the assessment standards.

A **recommendation** of the study is that systems of assessment and mechanisms are needed to prevent learner under-preparedness and to ascertain individual progress. Schools and teachers appear to need effective **progression signals** that ensure that their learners are performing at appropriate levels for their age grade and that they are actually prepared for and ready to be promoted to the next grade. Assessment of achievement levels through diagnostic testing would enable schools and teachers to monitor the achievement levels attained. Effective strategies also need to be in place as to what to do when learners are not reaching the levels required for promotion such as increasing the amount of time learners are engaged in learning.

In the final section of the thesis, I discuss the main limitation of the research model used and the methodological lessons learnt for future research.

4. METHODOLOGICAL LESSONS LEARNT

Firstly, from a methodological point of view, classroom practices and other variables probably need to be assessed on a larger-scale with much more precision. Essential characteristics of teacher-centred/learner-centred practices were identified in the study through the somewhat coarse-grained measures of pedagogical practices. Clearly, a challenge is to develop larger-scale observation instruments that are much more sensitive to quantitative and qualitative differences between practices in order to have the potential for identifying effective pedagogical practices more generally. In addition, learners' level of exposure to pedagogical practices was established in three lessons observations of each of the

thirty eight classes participating in the study. Chapter 4 discussed how, in a developed country context, Rowan, Correnti & Miller (2002: 26) submit that 'due to variation in daily instructional practice, roughly 15-20 observations are needed to derive reliable measures of instructional processes.' We still need to identify the minimum number of observations required for reliability in the South African context and the reliability of survey data.

In planning the study I faced a number of methodological decisions (outlined in section 2.3 in Chapter 4). One of these was whether to study gain across one year or whether to study overall achievement. I decided to investigate gain across one year through the use of pre- and post-test scores. The rationale for this decision was that in this way I could control for the effects of learners' school experiences prior to that school year. The idea was that relating achievement attained to measures of learners' exposure to 'Opportunity-to-Learn' and to particular pedagogical practices across one academic year would not control for exposure in previous grades as would measures of gain. This seemed important as all of the data collected pertained to learners' exposure to measure of the two focus constructs in 2003 with the exception of grade 5 *content coverage*. Controlling for prior achievement also seemed important because learners who started at lower levels of achievement could actually show larger gains which would not be reflected in 'once off' achievement scores. However, as explained in Chapter 4, a difficulty was that this model would potentially also control for 'the effects of differences in curriculum based on those prior experiences' (Schmidt & Burstein, 1992), in other words, for the effects of curricular pacing in prior years.

It turned out, subsequent data exploration suggested that greater inter-grade pacing over a number of school years may possibly be associated with higher mathematics scores rather than with increases in the achievement *gain* across a single school year. This lends support for the idea that curricular pacing is not related to *gain* measures because the pre-test removes a large part of the relationship between content coverage in earlier years which is more likely to show through differences in overall pre- and post-test scores than in gain. The study thus signals that inter-grade effects of pacing may not be identified through a model which investigates gain within one year through the use of pre- and post-test scores. It intimates that the effects of OTL on achievement might be of a longer term cumulative nature, and that comparing learning across the year reduces the influence of OTL variables.

The data exploration indicated that OTL has an across-grade effect which is not necessarily evident when one examines gain within a year in a model using only pre- and post-test scores. Findings suggest that the across-grade effects need to be considered in a different model which assesses cumulative effects on achievement over a much longer period of time. The implication is that, as long as interventions and evaluations in South Africa are based on models that focus on exposure to pedagogy over one year with one teacher in one classroom, only small effects on achievement will be evident. Longitudinal models using larger and more representative samples and focusing on across grade effects on achievement are what are needed.

Finally, this study is limited in terms of generalisability in that the applicability of its findings is restricted to low SES learners in the Western Cape. The sample comprises low SES learners in the Cape Peninsula and the demographics of the Western Cape differ from other provinces in South Africa. In the Western Cape, Afrikaans is the home language of a high proportion of low SES learners. Difference between the language spoken at home and the language of instruction at school is not as much of an issue as it is in other provinces.

5. CONCLUDING COMMENT

This study hopes to contribute to

- Bernstein's framework in relation to how 'the *what*' and 'the *how*' of schooling can be more delicately described within the same framework;
- the general area of school reform research thinking in South Africa regarding the significance of studying achievement across time-spans larger than one year in order to understand cumulative achievement; and
- policy in terms of factors which impact on learner achievement.

It is hoped that contributions to the above will help consolidate previous knowledge and suggest a way forward to further understandings.

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APPENDIX 1:

Sample, school fees and distribution of test items

Table 7: Number of schools, classes and learners from each District forming the original and achieved sample

Original sample				Achieved sample		
District	Schools	Classes	Learners	Schools	Classes	Learners
MC	3	3	51*	2	2	48
ME	6	8	241	6	7	184
MN	7	11	333	7	11	286
MS	9	18	539	9	18	483
Total	25	40	1 164	24	38	1 001

*Only two classes in MC wrote the pre-test and one of these classes had fewer than 30 learners in total.

Table 8: School fees

R30	R40	R50	R60	R80	R100	R120	R150	R180	R200
1	3	3	3	3	3	2	4	1	1

Table 9: Distribution of test items selected across NMLA outcomes

OUTCOME	'CLUSTERS'	NUMBER OF ITEMS
LO 1: NUMBER, OPERATIONS AND RELATIONSHIPS	Recognising, classifying and representing numbers	22
	Applications of numbers to problems	37
	Calculation types involving numbers	20
	Recognising and using properties of numbers	1
LO 3: SPACE, SHAPE AND GEOMETRY	Position	3
LO 4: MEASUREMENT:	Time	6
	Units and instruments-	
	a) mass, capacity and length b) perimeter, area, volume	16 11

APPENDIX 2:

Grade 6 pre- and post-test administration manuals

GRADE 6 PRE-TEST
ADMINISTRATION
MANUAL
2003
OPPORTUNITY TO LEARN RESEARCH PROJECT

YOUR RESPONSIBILITIES AS TEST ADMINSTRATOR

1. **Keep the tests confidential.** Do not show the tests to Principals, teachers, family members or friends. **No one** should see the tests but you and the learners.
2. **Administer** the tests to 30 grade 6 learners in selected Mathematics classes in the schools allocated to you unless there are fewer than 30 in a class in which case you must test the whole class. If grade 6 classes have different Maths teachers we are testing one class per teacher. If there is one Maths teacher for all grade 6 classes, or if a teacher teaches more than one class, then we have randomly selected just one of his/her classes for testing.
3. It is vitally important for our research task that learners are given **exactly the same:**
 - **Instructions** and
 - **Time** to complete the taskThis will make it possible to collect comparable data on learner attainment at each site.
4. **Mark** the numeracy/Mathematics tests of classes in the schools allocated to you. All test results must be treated in the strictest confidence.
5. **Return** the tests to your supervisor (in alphabetical order by surname according to the class list).

CHECKLIST FOR TEST ADMINISTRATORS

6. **The night before you visit a school**
 - Check **that** you have the box of tests for the school and that there are 31 tests in the box. The tests should be in the language of the learners of the school. If the school has bilingual classes, you will be given a box with tests in Afrikaans and English. These will be allocated according to the information we have been give by the teachers.
 - The box **should** contain
 - * 31 numeracy/Mathematics tests
 - * a class list with the names of the 30 learners to be tested indicated. In case of absentees or latecomers, you will need to randomly select the number of replacement learners needed to make up 30. Should this be necessary, note that you have done this and mark the names of the replacement learners on the class list. (In the case of bilingual classes the preferred language of each learner will be indicated on each class list and you will need to match the replacement learners with this information.)
 - You will also be given at least 10 extra pencils in case some learners do not have their own (Teacher have been asked to ensure that learners have pencils or pens and rulers).

7. The morning before you leave for school

- Make sure that you are on time. You **MUST** be at the schools **BEFORE** 8 a.m. in order to attain the planned timetable (see attached).
- Make sure that you have:
 - Directions to the school;
 - Your box of tests and extra pencils;
 - A watch/clock.

8. Arrival at school

- Greet the **principal** or relevant staff – be polite, but assert the urgency of your task.
- The **schools** should all be expecting you and should have a venue for the testing waiting for you. Go with the teacher to collect the learners pre-selected on the class list and take them straight to your testing venue. Teachers may not remain in the testing venue.
- If there are **more** than 30 in a class, not all learners will be tested so the rest of the class will need a teacher to supervise them in another classroom.

9. In the classroom

- Greet the learners and make them sit in alphabetical order by surname according to the class list. Make sure they are seated so that they are comfortable and not able to copy. If possible make them sit separately as their own desks, but if they have to share, seat a maximum of two learners per desk or table and put a partition such as a book bag between learners so that copying cannot occur.
- Check that they all have pens/pencils and access to rulers.
- Be sure that any help in the classroom that could effect the results is taken away, e.g. tables of multiplication or number lines on the walls or blackboard.
- Introduce yourself and explain that they will be writing a test. They must try their best because we need them to help us.
- Write the example questions on the board. (If you have to wait for learners to arrive, do this while you are waiting).
- Hand out the numeracy/ Mathemaitcs question paper and tell learners not to open their question papers until you tell them to do so.
- Tell them to write their first name and surname on the front of the question paper. **Check that this has been done and is legible.** This is **absolutely essential** as we will be **post-testing** the **same** learners at the end of the third term to check for learning gain. If we do not have their names accurately, we will not be able to use the pre-test data.
- Read the first question and demonstrate on the board what has to be done.

- Then say

If you do not know the answer to a question, do not waste time on it and do not guess the answer. Leave it and go on to the next question. It is important that you do not talk to each other or look at any one else's work. If you make a mistake cross the mistake out neatly like this (demonstrate how to cross out incorrect answers for multiple choice - circle with a cross through it.) If your pencil breaks during the test, please raise your hand immediately, and we will give you another pencil or pen.

- When you have finished with the examples and **brief** instructions, tell learners that they must now open their workbooks and work on their own. They must complete Task 1 only and stop when they get to the page where it says **STOP**.
- Take note of the time and write it down. Check that they are turning the page and **make sure** that they do not go on to the next task.
- Watch learners from the front of the class at all times
- **DO NOT INTERFERE WITH LEARNERS AND DO NOT ASSIST THEM. Say to them: Do it the way you think is right.**
- Watch learners at all times to ensure that they are turning over the pages of the test but that they are **not** proceeding with the next task, referring back to tasks that they are already supposed to have completed, or copying from or talking to each other.
- Keep an eye on the time and stop the learners when the time for the task is up. **MONITOR** the time that learners take to complete each task. Make a grid and monitor roughly how many complete the test after 10, 15, 20, etc. minutes.
- Tell learners that they will be able to go to the toilet during the 20 minute break. Before the 20 minute break, tell learners what time they must all be back in the classroom - make it 5 minutes before the end of the break. You must find a way to ensure that they **all** return timeously. During the break you can write the example questions for the next task on the board.

10. After the administration

- Collect all the tests (extras included) and **ENSURE** that that the completed scripts are in alphabetical order as presented on the class list.
- Wipe the example questions off the board and replace/restore any charts etc that you moved from the walls etc.
- Send a learner to call the teacher back to the classroom. Suggest that the class be given a short break.
- Thank the principal and others for the day before you leave the school.

11. Marking of literacy tests

- You are required to mark all the numeracy/Mathematics scripts as soon as you leave the school. All test results must remain absolutely confidential.
- Mark every item with a 0 or 1 score in the right margin:
 - 0 = wrong answer
 - 1 = correct answer
- The scripts must be returned personally to the following address
9 Bromley Road
Gleemoor
Athlone

- The following must also be returned
 - o Class lists with the box
 - o All tests including those not used
 - o The pencils
 - o Your time grid

These will be checked and payment will only be made when everything is complete.

12. Timetable

		Time if testing starts at 08h00
Introduction	10 minutes	08h10
Numeracy Task 1	40 minutes	08h50
Break	5 minutes (leg stretch)	08h55
Numeracy Task 2	35 minutes	09h30
Break	20 minutes	09h50
Numeracy Task 3	35 minutes	10h25
Break	5 minutes	10h30
Numeracy Task 4	30 minutes	11h00

END

GRADE 6 POST-TEST

ADMINISTRATION

MANUAL

2003

OPPORTUNITY TO LEARN RESEARCH PROJECT

YOUR RESPONSIBILITIES AS TEST ADMINSTRATOR

1. **Keep the tests confidential.** Do not show the tests to Principals, teachers, family members or friends. **No one** should see the tests but you and the learners.
2. **Administer** the tests to the same grade 6 learners as were tested in the pre-tests at the schools allocated to you. **It is absolutely essential that we post-testing the same learners at the end of the third term as we pre-tested at the beginning of the first term.** The lists of the names of learners to be tested are in the test boxes (note: where there were fewer than 30 in a class we pre-tested the whole class). At some schools we are testing more than one class at the school because the school has more than one grade 6 Maths teacher, in other words, we are testing learners from different teacher's classes. At other schools there is only one Maths teacher for all grade 6 classes and we are testing learners from one class.
3. It is vitally important for our research task that learners are given **exactly the same:**
 - a. **Instructions** and
 - b. **Time** to complete the taskThis will make it possible to collect comparable data on learner attainment at each site.
4. **Mark** the numeracy/Mathematics tests of classes in the schools allocated to you. All test results must be treated in the strictest confidence.
5. **Return** the tests to your supervisor (in the same order as the list of names in the test box).

CHECKLIST FOR TEST ADMINISTRATORS

1. **The night before you visit a school**
 - Check that you have the box of tests for the school and that there are 31 tests in the box. The tests should be in the language of the learning for the class.
 - The box should contain
 - * 31 **numeracy/Mathematics** tests
 - * a class list with the names of the (usually 30) learners to be tested indicated. In case of absentees or latecomers, you **do not** need to select replacement learners as we are **only** administering post-tests to those learners who wrote the pre-test. Mark the names of absentees on the list.
 - You will also be given a few extra pencils in case some learners do not have their own. Teacher have been asked to ensure that learners have pencils or pens and rulers.

2. The morning before you leave for school

- Make sure that you are on time. You **MUST** be at the schools **BEFORE** 8 a.m. in order to attain the planned timetable.
- Make sure that you have:
 - Directions and phone number for the school;
 - Your box of tests and extra pencils;
 - A watch/clock.

3. Arrival at school

- Greet the principal or relevant staff – be polite, but assert the urgency of your task.
- The schools should all be expecting you and should have a venue for the testing waiting for you. Go with the teacher to collect the learners pre-selected on the list and take them straight to your testing venue. **It is absolutely essential that you are post-testing the same learners at the end of the third term as we pre-tested at the beginning of the first term to check for learning gain.** Teachers may not remain in the testing venue.
- If not all the learners in the class are being tested, the rest of the class will need a teacher to supervise them in another classroom.

4. In the classroom

- Greet the learners and make them sit in order according to the list. Make sure they are seated so that they are comfortable and not able to copy. If possible make them sit separately at their own desks, but if they have to share, seat a maximum of two learners per desk or table and put a partition such as a book bag between learners so that copying cannot occur.
- Check that they all have pens/pencils and access to rulers.
- Be sure that any help in the classroom that could effect the results is taken away, e.g. tables of multiplication or number lines on the walls or blackboard.
- Introduce yourself and explain that they will be writing a test. They must try their best because we need them to help us.
- Write the example questions on the board. (If you have to wait for learners to arrive, do this while you are waiting).
- Hand out the numeracy/ Mathematics question paper and tell learners not to open their question papers until you tell them to do so.
- Tell them to write their first name and surname on the front of the question paper. **Check that this has been done and is legible.** If we do not have their names accurately, we will not be able to use them in conjunction with the pre-test data.
- Read the first question and demonstrate on the board what has to be done.

- Then say

If you do not know the answer to a question, do not waste time on it and do not guess the answer. Leave it and go on to the next question. It is important that you do not talk to each other or look at any one else's work. If you make a mistake cross the mistake out neatly like this (demonstrate how to cross out incorrect answers for multiple choice - circle with a cross through it.) If your pencil breaks during the test, please raise your hand immediately, and we will give you another pencil or pen.

- When you have finished with the examples and brief instructions, tell learners that they must now open their workbooks and work on their own. They must complete Task 1 only and stop when they get to the page where it says **STOP**.
- Take note of the time and write it down. **Check that they are turning the page and make sure that they do not go on to the next task.**
- Watch learners from the front of the class at all times
- **DO NOT INTERFERE WITH LEARNERS AND DO NOT ASSIST THEM. Say to them: Do it the way you think is right.**
- Watch learners at all times to ensure that they are turning over the pages of the test but that they are **not** proceeding with the next task, referring back to tasks that they are already supposed to have completed, or copying from or talking to each other.
- Keep an eye on the time and stop the learners when the time for the task is up. **MONITOR** the time that learners take to complete each task. Make a grid and monitor roughly how many complete the test after 10, 15, 20, etc. minutes.
- Tell learners that they will be able to go to the toilet during the 20 minute break. Before the 20 minute break, tell learners what time they must all be back in the classroom - make it 5 minutes before the end of the break. You must find a way to ensure that they **all** return timeously. During the break you can write the example questions for the next task on the board.

5. After the test administration

- Collect all the tests (**extras included**) and **ENSURE** that that the completed scripts are in order as presented on the list.
- Make sure that there are no missing pages from the back of the scripts.
- Hand out the learner questionnaires. Use the example questions to demonstrate how learners are expected to complete the answers. Read through each question and ensure that all learners understand what to do and are answering all the questions as you go along. Assist them as much as they need with this – there is no time limit. Make sure that they write their full names on the front of the questionnaires before you collect them.
- Wipe the example questions off the board and replace/restore any charts etc that you moved from the walls etc.
- Send a learner to call the teacher back to the classroom. Suggest that the class be given a short break.
- Thank the principal and others for the day before you leave the school.

6. Marking of literacy tests

- You are required to mark all the numeracy/Mathematics scripts as soon as you leave the school. All test results must remain absolutely confidential.
- Use the marking memo to mark every item with a 0 or 1 score in the right margin:
 - 0 = wrong answer
 - 1 = correct answer
- The scripts must be returned personally to the following address

- The following must also be returned
 - o Class lists with the box
 - o All tests including those not used
 - o The extra pencils
 - o Your time grid
 - o Your marking memo

These will be checked and payment will only be made when everything is complete.

7. Timetable

		Time if testing starts at 08h00
Introduction	10 minutes	08h10
Numeracy Task 1	40 minutes	08h50
Break	5 minutes (leg stretch)	08h55
Numeracy Task 2	35 minutes	09h30
Break	20 minutes	09h50
Numeracy Task 3	35 minutes	10h25
Break	5 minutes	10h30
Numeracy Task 4	30 minutes	11h00

END

APPENDIX 3:

Test Administrators' Questionnaireⁱ

Test administrator's name:

School:..... Grade 6

TEST ADMINISTRATION QUESTIONNAIRE

Administrators, please complete this questionnaire as accurately as possible after testing this class.

1. Were there any adverse factors / events / distractions affecting learners on the day of the testing?	Yes	1	No	2
2. If yes, please explain:				
3. Was there adequate seating space for learners to work on the tests without distraction/copying?	Yes	1	No	2
4. Did you have a watch or timer for accurately timing the testing session?	Yes	1	No	2
5. Was there an adequate supply of pencils?	Yes	1	No	2
Was there an adequate supply of rulers?	Yes	1	No	2
6. Did any learners have to leave the room during testing?	Yes	1	No	2
7. Were the learners given the stipulated length of time for the all the tasks?	Yes	1	No	2
8. If no, what was the time allocated? Task 1 Minutes Task 2 Minutes Task 3 Minutes Task 4 Minutes				
9. If no, what were the reasons for the difference:				
10. Did the majority of learners complete the test in the time allocated?	Yes	1	No	2
11. If yes, was the time allocated too generous?	Yes	1	No	2
12. Anything else which you think the Project needs to know about this data collection?				

ADAPTED FROM IEA (TIMSS) Results of the Quality Assurance Monitors' Test Session Observation.

APPENDIX 4:

‘Clusters’ for Learning Outcomes and Draft Intermediate framework for allocating time

Table 10: 'Clusters' for Learning Outcomes in the Intermediate Phase

LO 1: Number, operation and relationships	LO 2: Patterns, functions and algebra	LO 3: Space and Shape (geometry)	LO 4: Measurement	LO 5: Data handling
1. Recognising, classifying and representing numbers	1. Patterns	1. Shapes and Objects	4. Time	7. Collecting and Organising Data
2. Applications of numbers to problems	2. Equations	2. Transformations	5. Units and Instruments	8. Representing and Interpreting Data
3. Calculation types involving numbers	3.	3. Position	6. Perimeter, Area and Volume	9. Chance
4. Properties of numbers				

Table 13: Draft Intermediate framework for allocating time for each of the five Mathematics outcomes

LO1 NUMBER	40%
LO2 PATTERNS & FUNCTIONS, ALGEBRA	15%
LO3 SHAPE, SPACE, POSITION, GEOMETRY	30%
LO4 MEASUREMENT	
LO5 DATA HANDLING	15%

APPENDIX 5:

Grade 6 Curriculum Coverage, Exposure, Coherence and Emphasis Instrument

Teacher's full name: Grade 6 _____
School: Date: Data collector:.....

OPPORTUNITY-TO-LEARN

GRADE 6 MATHEMATICS

Curriculum Coverage, Exposure, Coherence and Emphasis Instrument
TERM 1, 2, 3 2003

Instructions to data collectors

If possible, first interview each grade 6 Maths teacher **whose class was tested** using the *OTL interview schedule*. Ideally you should use the interview information you have on the topics covered and the term/year plan as a means for determining which section/s of this instrument you should focus on when you examine the two learners' workbooks.

SECTION A

Examine the two most comprehensive of learners' workbooks and the two learner diaries of the daily content of lessons for the term. Use the latter and the information from the interview with the teacher and the term/year plan as supplementary data to the workbooks for completing Section A of this instrument by indicating

- a) the topics/subtopics covered in the term.
- b) the estimated number of lessons spent on each topic/subtopic covered in the term.
- c) the estimated total number of single Mathematics lessons this class had in the term (**section 7**)
- d) the order or sequence in which the topics were covered in the term (**section 8**).

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

1.1 RECOGNISING,		Covered	Ideal time	Estimated number of lessons
CLASSIFYING AND REPRESENTING				
NUMBERS				
Counting including:		Tick if yes	Number of single 30 min periods	Tick if less than one
Counting forwards and backwards in				
Whole numbers to				

• 2s (g4.5)				
• 3s (g4.5)				
• 5s (g4.5)				
• 10s (g4.5)				
• 25s (g4.5)				
• 50s (g4.5)				
• 100s (g4.5)				
• a variety of whole number intervals between 0 and 10 000 (g4.5)				
• fractions (g5)				
• decimals (g6)				
Representing and comparing whole numbers including zero and fractions including:				
• 4-digit numbers (g4)				
• 6-digit numbers (g5)				
• 9-digit numbers (g6)				
(Add and even number to 1 000 (g4)				
Common fractions in diagrammatic form (g4)				
Common fractions with different denominators including				
• halves (g4)				
• thirds (g4)				
• quarters (g4)				
• fifths (g4)				
• sixths (g4)				
• sevenths (g4)				
• eighths (g4)				
• tenths (g6)				
• twelfths (g5)				
• hundreds (g6)				
Common fractions including percentages (g6)				
Decimal fractions of the form 0.5, 1.5 and 2.5 etc. in the context of measurement (g4.5)				
Decimal fractions in at least two decimal places (g6)				
1 in terms of its multiplicative property (When a number is multiplied by its multiplicative inverse the answer is 1) (g5.6)				
Factors of any 2-digit whole number (g5)				
Multiples of single-digit numbers to 100 (g4.5)				
Multiples of any 2-digit whole number (g6)				
Multiples of any 3-digit whole number (g6)				
Prime numbers to 100 (g6)				
Place value of digits in whole numbers to:				
• 4-digit numbers (g4)				
• 6-digit numbers (g5)				
• 9-digit numbers (g6)				
Equivalent forms of the rational numbers including:				
Common fractions with denominators that are multiples of each other (g4.5)				
Common fractions with 1-digit or 2-digit denominators (g6)				

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	Covered	Ideal time	Estimated number of lessons	
	Tick if yes	Number of single 30 min periods	Tick if less than one	If one or more, estimate how many (write a number)
Equivalent forms of the rational numbers including: (CONTD)				
40	Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement (g4.5)			
	Decimal fractions to 2 decimal places (g6)	4		
	Percentages (g6)	2		
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS				
Solving problems in different contexts such as:				
43	Financial (e.g. buying and selling; profit and loss; simple budgets) (g4.5)			
	Financial (e.g. reading and interpreting accounts, discount) (g6)	6		
	Measurements in Natural Science and Technology contexts (g4.5,6)	1-3		
Solving problems that involve comparing:				
	• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2.5m to 1.5m = 5:3 or 5/3) (g4.5,6)	3		
	• two quantities of different kinds by division (i.e. rate e.g. kg/R, learners/teacher; km/hr; wages/day) (g4.5,6)	6		
Using operations appropriate to solving problems involving:				
Rounding off to the nearest				
4	• 10 (g4.5,6)	2-4		
4	• 100 (g4.5,6)	2-4		
5	• 1 000 (g4.5,6)	2-4		
5	• 5 (g5,6)	2-4		
Addition and subtraction of whole numbers with				
52	• 4 digits (g4)			
	• 5 digits (g5,6)	4-8		
54	Addition of common fractions in context (g4)			
55	Addition and subtraction of common fractions with the same denominator and whole numbers with common fractions (mixed numbers) (g5)			
	Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers) (g6)	8		
Multiplication of				
57	• whole 2-digit by 2-digit numbers (g4)			
58	• whole 3-digit by 2-digit numbers (g5)			
	• whole 4-digit by 3-digit numbers (g6)	6		
Division of				
60	• 3-digit by 1-digit whole numbers (g4)			
61	• 3-digit by 2-digit whole numbers (g5)			
	• 4-digit by 3-digit whole numbers (g6)	2-4		
63	Equal sharing with remainders (g4)			
	Finding fractions of whole numbers which result in whole numbers (g4.5,6)	4		
	Equivalent fractions (g5,6)	4		
	Addition and subtraction of positive decimals with 2 decimal places (g6)	4		

	Covered	Ideal time	Estimated number of lessons	
	Tick if yes	Number of single 30 min periods	Tick if less than one	If one or more, estimate how many (write a number)
Using operations appropriate to solving problems involving: (CONTD)				
Finding percentages of whole numbers (g6)		2		
Multiple operations on whole numbers with or without brackets (g6)		4		
1.3 CALCULATION TYPES INVOLVING NUMBERS				
Mental calculations involving:				
Addition (g4,5,6)		5		
Subtraction (g4,5,6)		5		
Multiplication of whole numbers up to				
• 10 x 10 (g4,5)				
• 12 x 12 (g6)		2-4		
Written and mental calculations with whole numbers involving:				
Adding and subtracting columns (g5, 6)		6		
Multiplying in columns (g6)		6		
Long division (g6)		8		
Building up and breaking down numbers (g4,5,6)				
Rounding off and compensating (g4,5,6)				
Doubling and halving (g4 & 5)				
Using a number line (g4)				
Using a calculator (g4,5,6)		4		
Using a range of strategies to check solutions and judge the reasonableness of solutions (g4,5,6)		6		
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS				
The reciprocal relationship between multiplication and division, e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$ (g4,5)				
The equivalence of division and fractions e.g. $1 \div 8 = 1/8$ (g4,5)				
Divisibility rules for				
• 2 (g6)		1		
• 5 (g6)		1		
• 10 (g6)		2		
• 100 (g6)		2		
• 1 000 (g6)		2		
The commutative properties with whole numbers [for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$; for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$)] (without learners necessarily teaching the term 'commutative') (g5,6)		4-6		
The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c - e.g. $(12 + 2) + 8 = 12 + (2 + 8)$; for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c - e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term 'associative') (g5,6)		4-6		
The distributive properties with whole numbers [for multiplication over addition: $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c - e.g. $5(3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term 'distributive') (g5,6)		3-5		

SECTION 2: MEASUREMENT

2.1 TIME

Reading and writing analogue, digital and 24-hour time including:

Analogue time (time read from a clock with a face and hands)

- to the nearest minute (g4.5.6)
- to the nearest second (g4.5.6)

Digital time (time read from a clock that has a continually changing digit display rather than a clock face)

- to the nearest minute (g4.5.6)
- to the nearest second (g4.5.6)

24-hour time

- to the nearest minute (g4.5.6)
- to the nearest second (g4.5.6)

Solving problems involving calculation and conversions between appropriate time units including:

- seconds (g4)
- minutes (g4)
- hours (g4)
- days (g4)
- weeks (g4)
- months (g4)
- years (g4)
- decades (g5)
- centuries (g5)
- millennia (g5)
- time zones and differences (g6)

Using time-measuring instruments with precision (accuracy) including:

- clocks (g4)
- watches (g4.5)
- stopwatches (g5)

2.2 UNITS AND INSTRUMENTS

2.2.1 MASS, CAPACITY AND LENGTH

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d'Unites); the universally-used system of scientific units) with appropriate precision (accuracy) for:

- Mass using kilograms (kg) (g4.5.6)
- Mass using grams (g) (g4.5.6)
- Capacity using litres (l) (g4.5.6)
- Capacity using millilitres (ml) (g4.5.6)
- Length using metres (m) (g4.5.6)
- Length using centimetres (cm) (g4.5.6)
- Length using millimetres (mm) (g4.5.6)
- Length using kilometres (km) (g4.5.6)
- Temperature using degree Celsius scale (g5.6)

Using measuring instruments for measuring:

Mass

- Using bathroom scales (g4.5.6)
- Using kitchen scales (g4.5.6)
- Using balances (g4.5.6)

Capacity

- Using measuring jugs (g4.5.6)

Length

- Using rulers (g4.5.6)
- Using meter sticks (g4.5.6)
- Using tape measures (g4.5.6)
- Using trundle wheels (g4.5.6)

Covered	Ideal time	Estimated number of lessons
Tick if yes	Number of single 30-min periods	Tick if less than one If one or more estimate how many (write a number)

	Covered	Ideal time	Estimated number of lessons	
			Tick if less than one	If one or more, estimate how many (write a number)
Temperature:				
• Using thermometers (g5.6)		1		
2.2.2 PERIMETER, AREA, VOLUME				
Measuring and approximating including:				
Perimeter:				
• Using rulers (g4.5 & 6)				
• Using measuring tapes (g4.5.6)		2		
Area of				
• polygons (using square grids and tiling) to develop understanding of square units (g4.5)				
• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles (g6)				
• circles (g6)				
• squares (g6)				
• rectangles (g6)		6		
Volume/capacity of				
• 3-D objects (by packing or filling them) to develop rules and understanding of cubic units (g4.5)				
• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms (g6)		?		
Investigation relationships between				
• the perimeter and area of rectangles (g6)				
• the perimeter and area of squares (g6)		2		
• surface area, volume and the dimensions of rectangular prisms (g6)		?		
Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:				
• Right angles (g5.6)				
• Angles smaller than right angles (g5.6)				
• Angles greater than right angles (g5.6)		4		
SECTION 3 : SPACE AND SHAPE (GEOMETRY):				
3.1 SHAPES AND OBJECTS				
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:				
• Rectangular prisms (g4)				
• Spheres (g4)				
• Cylinders (g4)				
• Prisms and pyramids (g4)				
• Circles (g4)				
• Rectangles (g4)				
• Polygons in terms of the number of sides up to 8 sided figures (g4)				
• Other objects (g4)				
Recognising and naming similarities and differences between:				
• squares and rectangles (g5)				
• cubes and rectangular prisms (g5)				
• tetrahedrons (a polyhedron with four faces) and other pyramids (g6)		2		
• rectangles and parallelograms (g6)		2		
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:				
• Shapes of faces (g4.5.6)				
• Number of sides (g4.5.6)				
• Number of faces (g5.6)		2		

	Covered	Ideal time	Estimated number of lessons	
			Tick if less than one	If one or more, estimate how many (write a number)
	Tick if yes	Number of single 30 min periods		
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to: (CONTD)				
160	• Flat and curved surfaces/straight and curved sides (g4)			
	• Edges (where two faces of a solid object meet) (g6)	2		
	• Vertices (the point where the arms of an angle meet; the point where edges of a polyhedron meet; the apex of a cone) (g6)	1		
	• Lengths of sides (g5 & 6)	1		
	• Angle size of corners (g6)	1		
Making 2-D and 3-D models				
165	• of geometric objects using cut out polygons (g4.5)			
166	• of geometric objects (example boxes) to trace nets (g5)			
	• by drawing shapes on grid paper (g4.5,6)	2		
	• using drinking straws to make a skeleton (g6)	1		
	• using nets (a flat diagram from which a model of a polyhedron can be made) (g6)	2		
	• using a pair of compasses to draw circles, patterns in circles and patterns with circles (g6)	4		
3.2 TRANSFORMATIONS				
171	Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms (g4)			
Using geometric figures and solids to recognise, describe and perform:				
172	• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position) (g5)			
173	• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed) (g5)			
174	• Translations (slides – a transformation under which a shape or object is moved by sliding into a new position) (g5)			
	Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry) (g6)	4		
Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:				
176	• Tessellations (tiling – formed by fitting shapes together to cover a plane without overlapping or leaving gaps) (g4.5)			
177	• Line symmetry (g4.5)			
178	• Rotational symmetry (g5)			
179	• Movement including rotations, reflections and translations (g5)			
	• Geometric properties (g4.5,6)	2		

	Covered	Ideal time	Estimated number of lessons	
			Tick if less than one	If one or more, estimate how many (write a number)
Drawing enlargements and reductions of 2-D shapes (at least quadrilaterals and triangles) using grid paper to compare their size and shape (g6)		2-4		
3.3 POSITION				
Describing changes in the view of an object held in different positions (g4)				
Describing views of a simple 3-D object from different positions (perspectives) (g5)				
Making sketches of a simple 3-D object from different positions (perspectives) (g6)		2		
Locating position on a coded (labelled) grid including maps:				
• from given instructions by column and row (g4)				
• by tracing paths between positions following verbal and written instructions (g5,6)				
Recognising maps as grids (g6)		2		
SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA:				
4.1 PATTERNS				
Investigating and extending numeric and geometric patterns:				
• Represented in physical or diagrammatic form (g4,5,6)		4		
• Not limited to sequences involving constant difference or ratio (g4,5,6)		4		
• Found in natural and cultural contexts (g4,5,6)				
• Of the learner's own creation (g4,5,6)				
• Represented in tables (g6)		4		
Describing observed relationships or rules of numeric and geometric patterns (g4,5,6)		4		
4.2 EQUATIONS				
Determining output values for given input values using:				
• Verbal descriptions (g4,5,6)				
• Flow diagrams (a diagram which shows the steps to be followed in solving a problem) (g4,5,6)				
• Tables (g6)				
Writing number sentences describing a problem situation including problems within contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues (g4,5,6)				
Solving or completing open number sentences by inspection or by trial-and-improvement, checking the solutions by substitution, e.g. $\div 4 = 12$ or $2x - 8 = 0$ (g5,6)		6		
4.3 EQUIVALENT REPRESENTATIONS				
Determining the equivalence of different descriptions of the same relationship or rule presented:				
• Verbally (g4,5,6)				
• In flow diagrams (g4,5,6)				
• By number sentences (g4,5,6)				
• In tables (g6)		2		

SECTION 5: DATA HANDLING:

5.1 COLLECTING AND ORGANISING DATA	Covered	Ideal time	Estimated number of lessons	
	Tick if yes	Number of single 30 min periods	Tick if less than one	If one or more, estimate how many (write a number)
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment (g4, 5, 6)				
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners (g5,6)				
Using tallies and tables to organise and record data (g5,6)		4		
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
• the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies (g4,5,6)		1		
• the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies (g5,6)		1		
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
• Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g4)				
• Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g5,6)				
• Bar graphs (uses vertical or horizontal bars to represent information) (g4,5,6)				
• Double bar graphs (g6)		2-4		
Reading and interpreting data presented in a variety of ways (including own representations and representations in the media – both words and graphs) to draw conclusions and make predictions sensitive to the role of:				
• Context (e.g. rural or urban, national or provincial) (g4,5,6)				
• Categories within the data (e.g. age, gender and race) (g5,6)				
• Other human rights issues (g4,5,6)		4		
5.3 CHANCE				
Comparing, classifying and ordering events from daily life on a scale from certain that they will happen to certain that they will not happen (g4,5)				
Predicting the likelihood of events in daily life based on observation and placing them on a scale from impossible to certain (g6)				



	Covered	Ideal time	Estimated number of lessons	
	Tick if yes	Number of single 10 min periods	Tick if less than one	If one or more, estimate how many (write a number)
Listing possible outcomes for simple experiments including:				
• tossing a coin (g5.6)		2		
• rolling a die (g5.6)				
• spinning a spinner (g5.6)				
Counting:				
• the number of possible outcomes for simple trials (g4)				
• the frequency of actual outcomes for a series of trials (g5.6)		4		

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SECTION 6: OTHER

Is there any other mathematics subject matter that was covered in the grade 6 mathematics class that is not listed above? YES/NO

If yes, please specify:

SECTION 7: ESTIMATED AMOUNT OF LESSONS SPENT ON MATHEMATICS

Use the information available to write down the estimated total number of single Mathematics lessons this class had in the third term:

SECTION 8: TOPIC SEQUENCE OR ORDER

Use the information available, in particular data from the learner's workbooks to write down the topics and subtopics in the order (sequence) in which they were covered in the term:

[illegible]

SECTION B

Now complete the following table with reference to the data reflected above:

Was the data collected on the topics covered easy to reconstruct, in other words was it 'as it appeared' and did the data allow you to feel strongly sure that you got the right information?	YES/NO
Was data collection on the topics covered difficult, and, however hard you tried to establish or reconstruct the topics covered, was it impossible as the data was simply not adequate enough?	YES/NO
Was the data collected on the estimated number of lessons spent on each topic easy to reconstruct, in other words was it 'as it appeared' and did the data allow you to feel strongly sure that you got the right information?	YES/NO
Was data collection on the estimated number of lessons spent on each topic difficult, and, however hard you tried to establish or reconstruct the estimated number of lessons spent on each topic, was it impossible as the data was simply not adequate enough?	YES/NO
Was the data collected on the order or sequence in which the topics were covered easy to reconstruct, in other words was it 'as it appeared' and did the data allow you to feel strongly sure that you got the right information?	YES/NO
Was data collection on the order or sequence in which the topics were covered difficult, and, however hard you tried to establish or reconstruct the sequence or order in which the topics were covered, was it impossible as the data was simply not adequate enough?	YES/NO

Please return the learners' workbooks but not the diaries. Keep the diaries and return them to me.

APPENDIX 6:

Grade 6 Teacher Survey Interview Schedule

Teacher's full name: Grade 6 _____
 School: I.O.I.T.: Date:

OPPORTUNITY-TO-LEARN GRADE 6 MATHEMATICS

TEACHER SURVEY INTERVIEW SCHEDULE: TERM 1,2 & 3 2003

Your school has been selected to participate in the Opportunity-to-Learn education policy study. The aim of the research is investigate grade 6 learners' opportunity to learn mathematics. Thank you for agreeing to participate. Your co-operation is greatly appreciated. Please answer the following questions as accurately as possible.

Cheryl Reeves
 School of Education
 University of Cape Town
 Phone (021) 689 1009

SECTION A ALLOCATED TIME AND TEACHING TIME

1.	How many minutes are allocated for a single mathematics lesson in grade 6?(Repeat these questions even though we asked them in term 1 & 2).....Minutes
2.	How many Mathematics lessons are formally scheduled for the Grade 6 class per week or cycle? Write the number If per cycle, specify how many days in a cycle:
3.	Estimate how many single Mathematics lessons your Grade 6 class missed overall in the third term?..... Write a number only
4.	Please provide reasons for the lessons missed (for example, teacher ill-health or personal bereavement, music/choir/athletics competitions, staff meetings, etc.) in the third term of 2003. <div style="border-top: 1px dotted black; height: 10px; margin-top: 5px;"></div> <div style="border-top: 1px dotted black; height: 10px; margin-top: 5px;"></div> <div style="border-top: 1px dotted black; height: 10px; margin-top: 5px;"></div> <div style="border-top: 1px dotted black; height: 10px; margin-top: 5px;"></div> <div style="border-top: 1px dotted black; height: 10px; margin-top: 5px;"></div>

SECTION B
MATHEMATICS SUBJECT MATTER COVERED IN TERM 3 2003

Please indicate whether the Grade 6 Mathematics class identified at the top of this page spent time on the following mathematics topics in the third term of 2003.

TOPIC	Covered in the third term			If yes, turn to page number
	Yes		No	
1. Number, operations and relationships		1	2	3
2. Measurement		1	2	6
3. Space and shape (geometry)		1	2	8
4. Patterns, functions and algebra		1	2	9
5. Data handling		1	2	10
6. Other		1	2	11

More detailed statements for the above topics will be provided in the next part of this schedule. Please provide the following details on each of the above topics covered in the third term and estimate the number of single mathematics lessons or periods that were spent on each aspect during the third term.

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS	Covered	Use Section C to collect data on the sequence order	Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Counting including:				
Counting forwards and backwards in				
• 2s				
• 3s				
• 5s				
• 10s				
• 25s				
• 50s				
• 100s				
• a variety of whole number intervals between 0 and 10 000				
• fractions				
• decimals				
Representing and comparing whole numbers including zero and fractions including:				
Whole numbers to				
• 4-digit numbers				
• 6-digit numbers				
• 9-digit numbers				
Odd and even number to 1 000				
Common fractions in diagrammatic form				
Common fractions with different denominators including				
• halves				
• thirds				
• quarters				
• fifths				
• sixths				
• sevenths				
• eighths				
• tenths				
• twelfths				
• hundreds				
Common fractions including percentages				
Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement				
Decimal fractions to at least two decimal places				
1 in terms of its multiplicative property [When a number is multiplied by its multiplicative inverse the answer is 1]				
Factors of any 2-digit whole number				
Multiples of single-digit numbers to 100				
Multiples of any 2-digit whole number				
Multiples of any 3-digit whole number				
Prime numbers to 100				

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Place value of digits in whole numbers to:			
• 4-digit numbers			
• 6-digit numbers			
• 9-digit numbers			
Equivalent forms of the rational numbers including			
Common fractions with denominators that are multiples of each other			
Common fractions with 1-digit or 2-digit denominators			
Decimal fractions of the form 0.5, 1.5 and 2.5 etc. in the context of measurement			
Decimal fractions to 2 decimal places			
Percentages			
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS			
Solving problems in different contexts such as:			
Financial (e.g. buying and selling; profit and loss; simple budgets)			
Financial (e.g. reading and interpreting accounts; discount)			
Measurements in Natural Science and Technology contexts			
Solving problems that involve comparing:			
• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2.5m to 1.5m = 5:3 or 5/3)			
• two quantities of different kinds by division (i.e. rate e.g. kg/R, learners/teacher; km/hr; wages/day)			
Using operations appropriate to solving problems involving:			
Rounding off to the nearest			
• 10			
• 100			
• 1 000			
• 5			
Addition and subtraction of whole numbers with			
• 4 digits			
• 5 digits			
Addition of common fractions in context			
Addition and subtraction of common fractions with the same denominator and whole numbers with common fractions (mixed numbers)			
Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers)			
Multiplication of			
• whole 2-digit by 2-digit numbers			
• whole 3-digit by 2-digit numbers			
• whole 4-digit by 3-digit numbers			

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Using operations appropriate to solving problems involving: (contd).			
Division of			
• whole 3-digit by 1-digit whole numbers			
• whole 3-digit by 2-digit whole numbers			
• whole 4-digit by 3-digit whole numbers			
Equal sharing with remainders			
Finding fractions of whole numbers which result in whole numbers			
Equivalent fractions			
Addition and subtraction of positive decimals with 2 decimal places			
Finding percentages of whole numbers			
Multiple operations on whole numbers with or without brackets			
1.3 CALCULATION TYPES INVOLVING NUMBERS			
Mental calculations involving:			
Addition			
Subtraction			
Multiplication of whole numbers up to			
• 10×10			
• 12×12			
Written and mental calculations with whole numbers involving:			
Adding and subtracting columns			
Multiplying in columns			
Long division			
Building up and breaking down numbers			
Rounding off and compensating			
Doubling and halving			
Using a number line			
Using a calculator			
Using a range of strategies to check solutions and judge the reasonableness of solutions			
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS			
The reciprocal relationship between multiplication and division: e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$			
The equivalence of division and fractions e.g. $1 \div 8 = 1/8$			
Divisibility rules for			
• 2			
• 5			
• 10			
• 100			
• 1 000			
The commutative properties with whole numbers [for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$]; for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$] (without learners necessarily teaching the term 'commutative')			

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c - e.g. $(12 + 2) + 8 = 12 + (2 + 8)$; for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c - e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term 'associative')				
The distributive properties with whole numbers [for multiplication over addition: $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c - e.g. $5(3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term 'distributive')				

SECTION 2: MEASUREMENT

2.1 TIME

Reading and writing analogue, digital and 24-hour time including:

Analogue time (time read from a clock with a face and hands)

- to the nearest minute
- to the nearest second

Digital time (time read from a clock that has a continually changing digit display rather than a clock face)

- to the nearest minute
- to the nearest second

24-hour time

- to the nearest minute
- to the nearest second

Solving problems involving calculation and conversions between appropriate time units including:

- seconds
- minutes
- hours
- days
- weeks
- months
- years
- decades
- centuries
- millennia
- time zones and differences

Using time-measuring instruments with precision (accuracy) including:

- clocks
- watches
- stopwatches

2.2 UNITS AND INSTRUMENTS

2.2.1 MASS, CAPACITY AND LENGTH

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d'Unités): the universally-used system of scientific units) with appropriate precision (accuracy) for:

- Mass using kilograms (kg)
- Mass using grams (g)
- Capacity using litres (l)
- Capacity using millilitres (ml)
- Length using metres (m)
- Length using centimetres (cm)
- Length using millimetres (mm)

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d'Unites): the universally-used system of scientific units) with appropriate precision (accuracy) for: (CONTD).				
• Length using kilometres (km)				
• Temperature using degree Celsius scale				
Using measuring instruments for measuring:				
Mass				
• Using bathroom scales				
• Using kitchen scales				
• Using balances				
Capacity				
• Using measuring jugs				
Length				
• Using rulers				
• Using meter sticks				
• Using tape measures				
• Using trundle wheels				
Temperature				
• Using thermometers				
2.2.2 PERIMETER, AREA, VOLUME				
Measuring and approximating including:				
Perimeter				
• Using rulers				
• Using measuring tapes				
Area of				
• polygons (using square grids and tiling) to develop understanding of square units				
• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles				
• circles				
• squares				
• rectangles				
Volume/capacity of				
• 3-D objects (by packing or filling them) to develop rules and understanding of cubic units				
• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms				
Investigation relationships between				
• the perimeter and area of rectangles				
• the perimeter and area of squares				
• surface area, volume and the dimensions of rectangular prisms				
Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:				
• Right angles				
• Angles smaller than right angles				
• Angles greater than right angles				

SECTION 3: SPACE AND SHAPE (GEOMETRY):

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
3.1 SHAPES AND OBJECTS			
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:			
• Rectangular prisms			
• Spheres			
• Cylinders			
• Prisms and pyramids			
• Circles			
• Rectangles			
• Polygons in terms of the number of sides up to 8 sided figures			
• Other objects			
Recognising and naming similarities and differences between:			
• squares and rectangles			
• cubes and rectangular prisms			
• tetrahedrons (a polyhedron with four faces) and other pyramids			
• rectangles and parallelograms			
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:			
• Shapes of faces			
• Number of sides			
• Number of faces			
• Flat and curved surfaces/straight and curved sides			
• Edges (where two faces of a solid object meet)			
• Vertices (the point where the arms of an angle meet; the point where edges of a polyhedron meet; the apex of a cone)			
• Lengths of sides			
• Angle size of corners			
Making 2-D and 3-D models			
• of geometric objects using cut out polygons			
• of geometric objects (example boxes) to trace nets			
• by drawing shapes on grid paper			
• using drinking straws to make a skeleton			
• using nets (a flat diagram from which a model of a polyhedron can be made)			
• using a pair of compasses to draw circles, patterns in circles and patterns with circles			
3.2 TRANSFORMATIONS			
Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms			
Using geometric figures and solids to recognise, describe and perform:			
• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position)			
• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed)			

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Using geometric figures and solids to recognise, describe and perform: (CONTD)				
• Translations (slides – a transformation under which a shape or object is moved by sliding into a new position)				
Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry)				
Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:				
• Tessellations (tiling – formed by fitting shapes together to cover a plane without overlapping or leaving gaps)				
• Line symmetry				
• Rotational symmetry				
• Movement including rotations, reflections and translations				
• Geometric properties				
Drawing enlargements and reductions of 2-D shapes (at least quadrilaterals and triangles) using grid paper to compare their size and shape				
3.3 POSITION				
Describing changes in the view of an object held in different positions				
Describing views of a simple 3-D object from different positions (perspectives)				
Making sketches of a simple 3-D object from different positions (perspectives)				
Locating position on a coded (labelled) grid including maps:				
• from given instructions by column and row				
• by tracing paths between positions following verbal and written instructions				
Recognising maps as grids				
SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA:				
4.1 PATTERNS				
Investigating and extending numeric and geometric patterns:				
• Represented in physical or diagrammatic form				
• Not limited to sequences involving constant difference or ratio				
• Found in natural and cultural contexts				
• Of the learner's own creation				
• Represented in tables				
Describing observed relationships or rules of numeric and geometric patterns				
4.2 EQUATIONS				
Determining output values for given input values using:				
• Verbal descriptions				
• Flow diagrams (a diagram which shows the steps to be followed in solving a problem)				

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Determining output values for given input values using: (CONTD.)				
• Tables				
Writing number sentences describing a problem situation including problems within contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues				
Solving or completing open number sentences by inspection or by trial-and-improvement, checking the solutions by substitution, e.g. $\square \div 4 = 12$ or $2 \times \square - 8 = 0$				
4.3 EQUIVALENT REPRESENTATIONS				
Determining the equivalence of different descriptions of the same relationship or rule presented:				
• Verbally				
• In flow diagrams				
• By number sentences				
• In tables				
SECTION 5: DATA HANDLING				
5.1 COLLECTING AND ORGANISING DATA				
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment				
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners				
Using tallies and tables to organise and record data				
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
• the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies				
• the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies				
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
• Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons)				
• Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons)				

APPENDIX 7:

LEVELS OF ACADEMIC ENGAGEMENT AND
CURRICULAR COHERENCE

Table 15: Scale to rate levels of academic engagement

0	1	2	3
In all three lesson observations learners do not appear to be equally engaged in Mathematics work. Some learners are reportedly not engaged in all Mathematics work during all three observations.	In two out of the three lesson observations learners do not appear to be equally engaged in Mathematics work. Some learners are reportedly not engaged in all Mathematics work during two of the three observations.	In two out of the three lesson observation learners appear to be equally engaged in Mathematics work. Some learners are reportedly not engaged in all Mathematics work during one of the three observations.	In all three lesson observations all learners appear to be equally engaged in Mathematics work. Learners are reportedly all engaged in all Mathematics work during the three observations.

Table 16: Matrix used to rate levels of curricular coherence

	1	2	3
Sequence	Sequence mostly does not reflect sequential development of maths concepts or procedures or difficult to discern development. Does not reflect links between sequential topics.	Sequence reflects sequential development of some maths concepts or procedures, however, links between sequential topics not always clear. For example, whole number work and fraction work mixed up or lots of operations with whole numbers before place value and counting or operations with whole numbers do not always progress from bigger numbers to smaller numbers	Sequence reflects gradual and sequential development of most maths concepts or procedures with isolated exceptions. For example, whole number work progresses from number concept development like place value and counting, factors and multiples to operations with numbers from smaller numbers to bigger numbers. Or, fraction and decimal work progresses from recognition and representation to equivalence, then operations. Reflects links between sequential topics, for example, fractions and decimals.
Spread	Shows poor spread of outcomes across the three terms. For example, only up to 3/4 outcomes dealt with so far; only 1/2 outcomes dealt with more than once.	Shows some spread of outcomes across the three terms. For example, most terms only one or two outcomes, up to 4 outcomes dealt with so far; only 3 outcomes dealt with more than once.	Shows good spread of outcomes across the three terms. For example, first term, more than one outcome; 2 nd and 3 rd terms more than two outcomes; all 5 outcomes dealt with so far; at least 4 outcomes dealt with more than once.

APPENDIX 8:

Grade 5 Curriculum Pacing Instrument

Teacher/'s' full name/s:

Grade/s 5

School: Date: Data collector:

OPPORTUNITY-TO-LEARN GRADE 5 MATHEMATICS

CURRICULUM PACING INSTRUMENT TERM 1, 2 & 3 2003

Instructions to data collectors

If possible, first interview each grade 5 Maths teacher using the *OTL interview schedule*. Ideally you should use the interview information you have on the topics covered and the term/year plan as a means for determining which section/s of the Curriculum Pacing Instrument you should focus on when you examine the GRADE 5 learners' workbooks for the term.

Examine the two most comprehensive of learners' workbooks and use the teacher's self-report data from the interview and term/lesson plan as supplementary sources to complete this *Curriculum Pacing Instrument* by indicating

- a) the topics covered in grade 5 in the first term.
- b) the estimated number of lessons spent on each topic covered in the first term.

N.B. First term - Can you ascertain or does the interview data indicate that all grade 5 teachers try to follow the same term/year plan and cover the same topics with all the classes and does *your examination of two learners' workbooks from each grade 5 class show evidence of alignment* in terms of the topics and amount of time spent on the topics? YES/NO.

SECTION A MATHEMATICS SUBJECT MATTER COVERED IN TERM 1, 2 & 3 2003

Please indicate whether the data available shows that the Grade 5 Mathematics class/es identified at the top of this page spent time on the following mathematics topics in this term of 2003 and the estimated number of lessons spent on each topic covered.

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS

Covered

Estimated number of lessons

Tick if yes

Tick if less than one

If one or more, estimate how many (write a number)

Ideal – number single 30 min periods

Counting including:

Counting forwards and backwards in

- 2s (g4.5)
- 3s (g4.5)
- 5s (g4.5)
- 10s (g4.5)
- 25s (g4.5)
- 50s (g4.5)
- 100s (g4.5)
- a variety of whole number intervals between 0 and 10 000 (g4.5)
- fractions (g5)
- decimals (g6)

Representing and comparing whole numbers including zero and fractions including:

Whole numbers to

- 4-digit numbers (g4)
- 6-digit numbers (g5)
- 9-digit numbers (g6)

Odd and even number to 1 000 (g4)

Common fractions in diagrammatic form (g4)

Common fractions with different denominators including

- halves (g4)
- thirds (g4)
- quarters (g4)
- fifths (g4)
- sixths (g4)
- sevenths (g4)
- eighths (g4)
- tenths (g6)
- twelfths (g5)
- hundreds (g6)

Common fractions including percentages (g6)

Decimal fractions of the form 0.5, 1.5 and 2.5 etc. in the context of measurement (g4.5)

Decimal fractions to at least two decimal places (g6)

1 in terms of its multiplicative property [When a number is multiplied by its multiplicative inverse the answer is 1] (g5.6)

Factors of any 2-digit whole number (g5)

Multiples of single-digit numbers to 100 (g4.5)

Multiples of any 2-digit whole number (g6)

Multiples of any 3-digit whole number (g6)

Prime numbers to 100 (g6)

	Covered		Estimated number of lessons		
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)	Ideal – number single 30 min periods
Place value of digits in whole numbers to:					
35		• 4-digit numbers (g4)			
37		• 6-digit numbers (g5)			4
		• 9-digit numbers (g6)			
Equivalent forms of the rational numbers including:					
		Common fractions with denominators that are multiples of each other (g4,5)			6-12
39		Common fractions with 1-digit or 2-digit denominators (g6)			
		Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement (g4,5)			2
41		Decimal fractions to 2 decimal places (g6)			
42		Percentages (g6)			
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS					
Solving problems in different contexts such as:					
		Financial (e.g. buying and selling, profit and loss; simple budgets) (g4,5)			6
44		Financial (e.g. reading and interpreting accounts, discount) (g6)			
		Measurements in Natural Science and Technology contexts (g4,5,6)			4
Solving problems that involve comparing:					
		• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2,5m to 1,5m = 5:3 or 5/3) (g4,5,6)			4
		• two quantities of different kinds by division (i.e. rate e.g. kg/R, learners/teacher, km/hr: wages/day) (g4,5,6)			6
Using operations appropriate to solving problems involving:					
Rounding off to the nearest					
		• 10 (g4,5,6)			2
		• 100 (g4,5,6)			1
		• 1 000 (g4,5,6)			1
		• 5 (g5,6)			1
Addition and subtraction of whole numbers with					
52		• 4 digits (g4)			
54		• 5 digits (g5,6)			6-8
		Addition of common fractions in context (g4)			
		Addition and subtraction of common fractions with the same denominator and whole numbers with common fractions (mixed numbers) (g5)			6-8
56		Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers) (g6)			
Multiplication of					
57		• whole 2-digit by 2-digit numbers (g4)			
59		• whole 3-digit by 2-digit numbers (g5)			6
		• whole 4-digit by 3-digit numbers (g6)			
Division of					
60		• whole 3-digit by 1-digit numbers whole numbers (g4)			
		• whole 3-digit by 2-digit whole numbers (g5)			6
62		• whole 4-digit by 3-digit whole numbers (g6)			

	Covered		Estimated number of lessons		
			<i>Tick if less than one</i>	<i>If one or more, estimate how many (write a number)</i>	<i>Ideal – number single 30 min periods</i>
63		Equal sharing with remainders (g4)			
		Finding fractions of whole numbers which result in whole numbers (g4,5,6)			8
		Equivalent fractions (g5,6)			6-8
66		Addition and subtraction of positive decimals with 2 decimal places (g6)			
67		Finding percentages of whole numbers (g6)			
68		Multiple operations on whole numbers with or without brackets (g6)			
1.3 CALCULATION TYPES INVOLVING NUMBERS					
Mental calculations involving:					
		Addition (g4,5,6)			6
		Subtraction (g4,5,6)			6
		Multiplication of whole numbers up to			
		• 10×10 (g4,5)			6
72		• 12×12 (g6)			
Written and mental calculations with whole numbers involving:					
		Adding and subtracting columns (g5, 6)			6
74		Multiplying in columns (g6)			
75		Long division (g6)			
		Building up and breaking down numbers (g4,5,6)			6
		Rounding off and compensating (g4,5,6)			5
		Doubling and halving (g4 & 5)			4
79		Using a number line (g4)			
		Using a calculator (g4,5,6)			6
		Using a range of strategies to check solutions and judge the reasonableness of solutions (g4,5,6)			4
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS					
		The reciprocal relationship between multiplication and division, e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$ (g4,5)			4
		The equivalence of division and fractions e.g. $1 \div 8 = 1/8$ (g4,5)			2
		Divisibility rules for			
84		• 2 (g6)			
85		• 5 (g6)			
86		• 10 (g6)			
87		• 100 (g6)			
88		• 1 000 (g6)			
		The commutative properties with whole numbers [for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$]; for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$)] (without learners necessarily teaching the term 'commutative') (g5,6)			2
		The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c - e.g. $(12 + 2) + 8 = 12 + (2 + 8)$; for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c - e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term 'associative') (g5,6)			2

	Covered		Estimated number of lessons		
	Tick if yes		Less than one	1 or more, estimate how many	Ideal number
The distributive properties with whole numbers [for multiplication over addition; $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c e.g. $5 \times (3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term 'distributive') (g5,6)					2-4

SECTION 2: MEASUREMENT

2.1 TIME

Reading and writing analogue, digital and 24-hour time including:

Analogue time (time read from a clock with a face and hands)

• to the nearest minute (g4,5,6)					2
• to the nearest second (g4,5,6)					2

Digital time (time read from a clock that has a continually changing digit display rather than a clock face)

• to the nearest minute (g4,5,6)					1
• to the nearest second (g4,5,6)					1

24-hour time

• to the nearest minute (g4,5,6)					1-2
• to the nearest second (g4,5,6)					1-2

Solving problems involving calculation and conversions between appropriate time units including:

• seconds (g4)					
• minutes (g4)					
• hours (g4)					
• days (g4)					
• weeks (g4)					
• months (g4)					
• years (g4)					
• decades (g5)					1
• centuries (g5)					1
• millennia (g5)					1
• time zones and differences (g6)					

Using time-measuring instruments with precision (accuracy) including:

• clocks (g4)					
• watches (g4,5)					1
• stopwatches (g5)					1

2.2 UNITS AND INSTRUMENTS

2.2.1 MASS, CAPACITY AND LENGTH

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units with precision for:

• Mass using kilograms (kg) (g4,5,6)					2
• Mass using grams (g) (g4,5,6)					2
• Capacity using litres (l) (g4,5,6)					2
• Capacity using millilitres (ml) (g4,5,6)					2
• Length using metres (m) (g4,5,6)					2
• Length using centimetres (cm) (g4,5,6)					2
• Length using millimetres (mm) (g4,5,6)					2
• Length using kilometres (km) (g4,5,6)					2
• Temperature using degree Celsius scale (g5,6)					1

Using measuring instruments for measuring:

Mass					
• Using bathroom scales (g4,5,6)					2
• Using kitchen scales (g4,5,6)					2
• Using balances (g4,5,6)					2
Capacity					
• Using measuring jugs (g4,5,6)					2

	Covered		Estimated no. lessons		
	Tick if yes		Tick if less than one	If one or more, estimate how many	Ideal – number single 30 min periods
Length					
• Using rulers (p4,5,6)					2
• Using meter sticks (p4,5,6)					2
• Using tape measures (p4,5,6)					2
• Using trundle wheels (p4,5,6)					2
Temperature:					
• Using thermometers (p5,6)					2
2.2.2 PERIMETER, AREA, VOLUME					
Measuring and approximating including:					
Perimeter:					
• Using rulers (p4,5 & 6)					2
• Using measuring tapes (p4,5,6)					2
Area of					
• polygons (using square grids and tiling) to develop understanding of square units (p4,5)					4
• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles (p6)					
• circles (p6)					
• squares (p6)					
• rectangles (p6)					
Volume/capacity of					
• 3-D objects (by packing or filling them) to develop rules and understanding of cubic units (p4,5)					4
• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms (p6)					
Investigation relationships between					
• the perimeter and area of rectangles (p6)					
• the perimeter and area of squares (p6)					
• surface area, volume and the dimensions of rectangular prisms (p6)					
Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:					
• Right angles (p5,6)					2
• Angles smaller than right angles (p5,6)					2
• Angles greater than right angles (p5,6)					1
SECTION 3 : SPACE AND SHAPE (GEOMETRY):					
3.1 SHAPES AND OBJECTS					
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:					
• Rectangular prisms (p4)					
• Spheres (p4)					
• Cylinders (p4)					
• Prisms and pyramids (p4)					
• Circles (p4)					
• Rectangles (p4)					
• Polygons in terms of the number of sides up to 8 sided figures (p4)					
• Other objects (p4)					
Recognising and naming similarities and differences between:					
• squares and rectangles (p5)					2
• cubes and rectangular prisms (p5)					2
• tetrahedrons (a polyhedron with four faces) and other pyramids (p6)					

	Covered		Estimated no. lessons		
			Tick if less than one	If one or more estimate how many	Ideal number single 30 min periods
156		• rectangles and parallelograms (p6)			
		Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:			
		• Shapes of faces (p4,5,6)			1
		• Number of sides (p4,5,6)			1
		• Number of faces (p5,6)			1
160		• Flat and curved surfaces/straight and curved sides (p4)			
161		• Edges (where two faces of a solid object meet) (p6)			
162		• Vertices (the point where the arms of an angle meet; the point where edges of a polyhedron meet; the apex of a cone) (p6)			
		• Lengths of sides (p5 & 6)			2
164		• Angle size of corners (p6)			
		Making 2-D and 3-D models			
		• of geometric objects using cut out polygons (p4,5)			4
		• of geometric objects (example boxes) to trace nets (p5)			4
		• by drawing shapes on grid paper (p4,5,6)			4
168		• using drinking straws to make a skeleton (p6)			
169		• using nets (a flat diagram from which a model of a polyhedron can be made) (p6)			
170		• using a pair of compasses to draw circles, patterns in circles and patterns with circles (p6)			
		3.2 TRANSFORMATIONS			
171		Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms (p4)			
		Using geometric figures and solids to recognise, describe and perform:			
		• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position) (p5)			2
		• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed) (p5)			2
		• Translations (slides – a transformation under which a shape or object is moved by sliding into a new position) (p5)			2
175		Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry) (p6)			
		Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:			
		• Tessellations (tiling – formed by fitting shapes together to cover a plane without overlapping or leaving gaps) (p4,5)			4
		• Line symmetry (p4,5)			2
		• Rotational symmetry (p5)			2
		• Movement including rotations, reflections and translations (p5)			4
180		• Geometric properties (p4,5,6)			2-4

	Covered	Tick if yes	Estimated no. lessons		
			Tick if less than one	If one or more, estimate how many	Ideal number single 30 min periods
181					
3.3 POSITION					
182					
184					4
185					
187					4
SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA:					
4.1 PATTERNS					
Investigating and extending numeric and geometric patterns:					
192					2
					2
					4
					2
					8
4.2 EQUATIONS					
Determining output values for given input values using:					
196					2
					2
					2-4
					2-4
4.3 EQUIVALENT REPRESENTATIONS					
Determining the equivalence of different descriptions of the same relationship or rule presented:					
199					2
200					2
201					2
202					

SECTION 5: DATA HANDLING:

5.1 COLLECTING AND ORGANISING DATA	Covered	Estimated number of lessons		
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)	Ideal – number single 30 min periods
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment (p4, 5,6)				2
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners (p5,6)				4
Using tallies and tables to organise and record data (p5,6)				2
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
<ul style="list-style-type: none"> the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies (p4,5,6) 				2
<ul style="list-style-type: none"> the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies (p5,6) 				2
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
<ul style="list-style-type: none"> Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons) (p4) 				
<ul style="list-style-type: none"> Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons) (p5,6) 				2
<ul style="list-style-type: none"> Bar graphs (uses vertical or horizontal bars to represent information) (p4,5,6) 				2-4
<ul style="list-style-type: none"> Double bar graphs (p6) 				2
Reading and interpreting data presented in a variety of ways (including own representations and representations in the media – both words and graphs) to draw conclusions and make predictions sensitive to the role of:				
<ul style="list-style-type: none"> Context (e.g. rural or urban, national or provincial) (p4,5,6) 				2
<ul style="list-style-type: none"> Categories within the data (e.g. age, gender and race) (p5,6) 				1
<ul style="list-style-type: none"> Other human rights issues (p4,5,6) 				1
5.3 CHANCE				
Comparing, classifying and ordering events from daily life on a scale from certain that they will happen to certain that they will not happen (p4,5)				2
Predicting the likelihood of events in daily life based on observation and placing them on a scale from impossible to certain (p6)				

	Covered		Estimated number of lessons		
				If one or more, estimate how many (write a number)	Ideal number single 30 min periods
	Tick if yes		Tick if less than one		
Listing possible outcomes for simple experiments including:					
• tossing a coin (g5,6)					1
• rolling a die (g5,6)					1
• spinning a spinner (g5,6)					1
Counting:					
• the number of possible outcomes for simple trials (g4)					
• the frequency of actual outcomes for a series of trials (g5,6)					2

SECTION 6: OTHER

Is there any other mathematics subject matter that was covered in the grade 5 mathematics class that is not listed above? YES/NO

If yes, please specify:

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SECTION B

Data collectors, please complete the following table:

Was the data collected on the topics covered easy to reconstruct, in other words was it 'as it appeared' and did the data allow you to feel strongly sure that you got the right information?	YES/NO
Was data collection on the topics covered difficult, and, however hard you tried to establish or reconstruct the topics covered, was it impossible as the data was simply not adequate enough?	YES/NO
Was the data collected on the estimated number of lessons spent on each topic easy to reconstruct, in other words was it 'as it appeared' and did the data allow you to feel strongly sure that you got the right information?	YES/NO
Was data collection on the estimated number of lessons spent on each topic difficult, and, however hard you tried to establish or reconstruct the estimated number of lessons spent on each topic, was it impossible as the data was simply not adequate enough?	YES/NO

Please return the learners' workbooks.

APPENDIX 9:

Grade 5 Teacher Survey Interview Schedule

Teacher's/ full name/a: Grade 5
 School: LOIT: Date:

OPPORTUNITY-TO-LEARN
GRADE 5 MATHEMATICS
TEACHER SURVEY INTERVIEW SCHEDULE:
TERM 1, 2 & 3
2003

Your school is participating in the Opportunity-to-Learn education policy study. Thank you for agreeing to participate – your co-operation is greatly appreciated. The aim of the research is investigate grade 6 learners' opportunity to learn mathematic. An aspect of this study includes collecting data on the content that is being covered at the grade 5 level at each school. Please answer the following questions about the grade 5 Mathematics class/es as accurately as possible.

Cheryl Reeves (School of Education, University of Cape Town)
 10 Croft Rd
 RONDEBOSCH
 7700
 Phone (021) 689 1009

Term 1

1. Did all grade 5 teachers follow the same term/year plan and cover the same topics with all the grade 5 Mathematics classes, in other words, is there supposed to be alignment across grade 5 in terms of the topics taught and amount of time spent on the topics?
 YES/NO.

SECTION A
MATHEMATICS SUBJECT MATTER COVERED IN TERM 1, 2 & 3 2003

Please indicate whether the Grade 5 class/es has/have spent time on the following mathematics topics in this term of 2003.

TOPIC	Covered in the third term		If yes, turn to page number
	Yes	No	
1. Number, operations and relationships	1	2	2
2. Measurement	1	2	5
3. Space and shape (geometry)	1	2	7
4. Patterns, functions and algebra	1	2	8
5. Data handling	1	2	9
6. Other	1	2	10

More detailed statements for the above topics are provided in the following section. Please complete the details for each of the above topics covered in the term and tick the box that describes the estimated number of **single mathematics lessons** or periods spent on each aspect during the term. (Data collectors: It is not necessary to indicate the order in which they were covered for grade 5).

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Counting including:			
Counting forwards and backwards in			
• 2s			
• 3s			
• 5s			
• 10s			
• 25s			
• 50s			
• 100s			
• a variety of whole number intervals between 0 and 10 000			
• fractions			
• decimals			
Representing and comparing whole numbers including zero and fractions including:			
Whole numbers to			
• 4-digit numbers			
• 6-digit numbers			
• 9-digit numbers			
Odd and even number to 1 000			
Common fractions in diagrammatic form			
Common fractions with different denominators including			
• halves			
• thirds			
• quarters			
• fifths			
• sixths			
• sevenths			
• eighths			
• tenths			
• twelfths			
• hundreds			
Common fractions including percentages			
Decimal fractions of the form 0.5, 1.5 and 2.5 etc. in the context of measurement			
Decimal fractions to at least two decimal places			
1 in terms of its multiplicative property [When a number is multiplied by its multiplicative inverse the answer is 1]			
Factors of any 2-digit whole number			
Multiples of single-digit numbers to 100			
Multiples of any 2-digit whole number			
Multiples of any 3-digit whole number			
Prime numbers to 100			

	Covered	Estimated number of sessions	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Place value of digits in whole numbers to:			
• 4-digit numbers			
• 6-digit numbers			
• 9-digit numbers			
Equivalent forms of the rational numbers including:			
Common fractions with denominators that are multiples of each other			
Common fractions with 1-digit or 2-digit denominators			
Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement			
Decimal fractions to 2 decimal places			
Percentages			
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS			
Solving problems in different contexts such as:			
Financial (e.g. buying and selling, profit and loss, simple budgets)			
Financial (e.g. reading and interpreting accounts, discount)			
Measurements in Natural Science and Technology contexts			
Solving problems that involve comparing:			
• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2,5m to 1,5m = 5:3 or 5/3)			
• two quantities of different kinds by division (i.e. rate e.g. kg/R, learners/teacher, km/hr, wages/day)			
Using operations appropriate to solving problems involving:			
Rounding off to the nearest			
• 10			
• 100			
• 1 000			
• 5			
Addition and subtraction of whole numbers with			
• 4 digits			
• 5 digits			
Addition of common fractions in context			
Addition and subtraction of common fractions with the same denominator and whole numbers with common fractions (mixed numbers)			
Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers)			
Multiplication of			
• whole 2-digit by 2-digit numbers			
• whole 3-digit by 2-digit numbers			
• whole 4-digit by 3-digit numbers			

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Using operations appropriate to solving problems involving: (contd).			
Division of			
• whole 3-digit by 1-digit whole numbers			
• whole 3-digit by 2-digit whole numbers			
• whole 4-digit by 3-digit whole numbers			
Equal sharing with remainders			
Finding fractions of whole numbers which result in whole numbers			
Equivalent fractions			
Addition and subtraction of positive decimals with 2 decimal places			
Finding percentages of whole numbers			
Multiple operations on whole numbers with or without brackets			
1.3 CALCULATION TYPES INVOLVING NUMBERS			
Mental calculations involving:			
Addition			
Subtraction			
Multiplication of whole numbers up to			
• 10×10			
• 12×12			
Written and mental calculations with whole numbers involving:			
Adding and subtracting columns			
Multiplying in columns			
Long division			
Building up and breaking down numbers			
Rounding off and compensating			
Doubling and halving			
Using a number line			
Using a calculator			
Using a range of strategies to check solutions and judge the reasonableness of solutions			
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS			
The reciprocal relationship between multiplication and division, e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$			
The equivalence of division and fractions e.g. $1 \div 8 = 1/8$			
Divisibility rules for			
• 2			
• 5			
• 10			
• 100			
• 1 000			
The commutative properties with whole numbers [(for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$); for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$)] (without learners necessarily teaching the term 'commutative')			

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c – e.g. $(12 + 2) + 8 = 12 + (2 + 8)$; for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c – e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term ‘associative’)			
The distributive properties with whole numbers [for multiplication over addition: $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c – e.g. $5(3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term ‘distributive’)			

SECTION 2: MEASUREMENT

2.1 TIME

Reading and writing analogue, digital and 24-hour time including:

Analogue time (time read from a clock with a face and hands)

- to the nearest minute
- to the nearest second

Digital time (time read from a clock that has a continually changing digit display rather than a clock face)

- to the nearest minute
- to the nearest second

24-hour time

- to the nearest minute
- to the nearest second

Solving problems involving calculation and conversions between appropriate time units including:

- seconds
- minutes
- hours
- days
- weeks
- months
- years
- decades
- centuries
- millennia
- time zones and differences

Using time-measuring instruments with precision (accuracy) including:

- clocks
- watches
- stopwatches

2.2 UNITS AND INSTRUMENTS

2.2.1 MASS, CAPACITY AND LENGTH

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d’Unités): the universally-used system of scientific units) with appropriate precision (accuracy) for:

- Mass using kilograms (kg)
- Mass using grams (g)
- Capacity using litres (l)
- Capacity using millilitres (ml)
- Length using metres (m)
- Length using centimetres (cm)
- Length using millimetres (mm)

	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d'Unites): the universally-used system of scientific units) with appropriate precision (accuracy) for: (CONTD).			
• Length using kilometres (km)			
• Temperature using degree Celsius scale			
Using measuring instruments for measuring:			
Mass			
• Using bathroom scales			
• Using kitchen scales			
• Using balances			
Capacity			
• Using measuring jugs			
Length			
• Using rulers			
• Using meter sticks			
• Using tape measures			
• Using trundle wheels			
Temperature			
• Using thermometers			
2.2.2 PERIMETER, AREA, VOLUME			
Measuring and approximating including:			
Perimeter			
• Using rulers			
• Using measuring tapes			
Area of			
• polygons (using square grids and tiling) to develop understanding of square units			
• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles			
• circles			
• squares			
• rectangles			
Volume/capacity of			
• 3-D objects (by packing or filling them) to develop rules an understanding of cubic units			
• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms			
Investigation relationships between			
• the perimeter and area of rectangles			
• the perimeter and area of squares			
• surface area, volume and the dimensions of rectangular prisms			
Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:			
• Right angles			
• Angles smaller than right angles			
• Angles greater than right angles			

SECTION 3: SPACE AND SHAPE (GEOMETRY):

3.1 SHAPES AND OBJECTS	Covered	Estimated number of lessons	
	Tick if yes	Tick if less than one	If one or more, estimate how many (write a number)
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:			
• Rectangular prisms			
• Spheres			
• Cylinders			
• Prisms and pyramids			
• Circles			
• Rectangles			
• Polygons in terms of the number of sides up to 8 sided figures			
• Other objects			
Recognising and naming similarities and differences between:			
• squares and rectangles			
• cubes and rectangular prisms			
• tetrahedrons (a polyhedron with four faces) and other pyramids			
• rectangles and parallelograms			
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:			
• Shapes of faces			
• Number of sides			
• Number of faces			
• Flat and curved surfaces/straight and curved sides			
• Edges (where two faces of a solid object meet)			
• Vertices (the point where the arms of an angle meet; the point where edges of a polyhedron meet; the apex of a cone)			
• Lengths of sides			
• Angle size of corners			
Making 2-D and 3-D models			
• of geometric objects using cut out polygons			
• of geometric objects (example boxes) to trace nets			
• by drawing shapes on grid paper			
• using drinking straws to make a skeleton			
• using nets (a flat diagram from which a model of a polyhedron can be made)			
• using a pair of compasses to draw circles; patterns in circles and patterns with circles			
3.2 TRANSFORMATIONS			
Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms			
Using geometric figures and solids to recognise, describe and perform:			
• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position)			
• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed)			

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Using geometric figures and solids to recognise, describe and perform: (CONTD)				
<ul style="list-style-type: none">Translations (slides - a transformation under which a shape or object is moved by sliding into a new position)				
Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry)				
Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:				
<ul style="list-style-type: none">Tessellations (tiling -- formed by fitting shapes together to cover a plane without overlapping or leaving gaps)				
<ul style="list-style-type: none">Line symmetry				
<ul style="list-style-type: none">Rotational symmetry				
<ul style="list-style-type: none">Movement including rotations, reflections and translations				
<ul style="list-style-type: none">Geometric properties				
Drawing enlargements and reductions of 2-D shapes (at least quadrilaterals and triangles) using grid paper to compare their size and shape				
3.3 POSITION				
Describing changes in the view of an object held in different positions				
Describing views of a simple 3-D object from different positions (perspectives)				
Making sketches of a simple 3-D object from different positions (perspectives)				
Locating position on a coded (labelled) grid including maps:				
<ul style="list-style-type: none">from given instructions by column and row				
<ul style="list-style-type: none">by tracing paths between positions following verbal and written instructions				
Recognising maps as grids				
SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA:				
4.1 PATTERNS				
Investigating and extending numeric and geometric patterns:				
<ul style="list-style-type: none">Represented in physical or diagrammatic form				
<ul style="list-style-type: none">Not limited to sequences involving constant difference or ratio				
<ul style="list-style-type: none">Found in natural and cultural contexts				
<ul style="list-style-type: none">Of the learner's own creation				
<ul style="list-style-type: none">Represented in tables				
Describing observed relationships or rules of numeric and geometric patterns				
4.2 EQUATIONS				
Determining output values for given input values using:				
<ul style="list-style-type: none">Verbal descriptions				
<ul style="list-style-type: none">Flow diagrams (a diagram which shows the steps to be followed in solving a problem)				

	Covered		Estimated number of lessons	
	Tick if yes		Tick if less than one	If one or more, estimate how many (write a number)
Determining output values for given input values using: (CONTD.)				
• Tables				
Writing number sentences describing a problem situation including problems within contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues				
Solving or completing open number sentences by inspection or by trial-and-improvement, checking the solutions by substitution, e.g. $\square \div 4 = 12$ or $2 \times \square - 8 = 0$				
4.2 EQUIVALENT REPRESENTATIONS				
Determining the equivalence of different descriptions of the same relationship or rule presented:				
• Verbally				
• In flow diagrams				
• By number sentences				
• In tables				
SECTION 5: DATA HANDLING				
5.1 COLLECTING AND ORGANISING DATA				
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment				
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners				
Using tallies and tables to organise and record data				
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
• the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies				
• the endpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies				
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
• Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons)				
• Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons)				

SECTION B TERM PLAN OR SCHEME OF WORK

1.	Is a written plan for grade 5 mathematics for the third term available? YES/NO <i>(If available, obtain a copy and attach it copy to this form and refer to the term plan when asking the following questions.)</i>	
2.	Did you cover all the mathematics subject matter (topics and subtopics) outlined in this plan of work for the third term as intended?	YES/NO
3.	If no, which of the topics/subtopics listed were left out in the third term?	
4.	Did you cover other mathematics subject matter in the third term that is not reflected on your written plan?	YES/NO
5.	If yes, what topics or subtopics were these?	

SECTION C LEARNERS' WORK BOOKS

*Ask the teacher for the two most comprehensive grade 5 Mathematics work books or files from learners so that you can use the workbooks to complete the **GRADE 5 Curriculum Pacing Instrument**.*

The information obtained through the interview with the teacher should help orientate you regarding the contents you expect to find covered in the learners' workbooks.

SAY: THANK YOU for the thought, time and effort you have put into this interview and attach a copy of the term/year plan to this schedule.

APPENDIX 10:

Lesson Observation Schedule

LESSON OBSERVATION SCHEDULE: PART 1

SECTION 1: TYPE OF PEDAGOGY				
CLASSIFICATION - POWER	ALWAYS C- (4)	MOSTLY C- (3)	MOSTLY C+ (2)	ALWAYS C++ (1)
Instructional context				
RELATIONS BETWEEN DISCOURSES: INTER-DISCURSIVE RELATIONSHIPS				
Degree to which the boundary between Mathematics knowledge and everyday knowledge is distinct or 'blurred'				
1. SCHOOL MATHEMATICS AND EVERYDAY KNOWLEDGE	Mathematics knowledge is always related to everyday knowledge. For example, through the embedding of maths knowledge in 'real world' problems or through the application of maths knowledge in real world applications, etc.	Mathematics knowledge is mostly related to everyday knowledge. For example, through the recruitment of everyday knowledge to support conceptual development of maths knowledge or through the application of maths knowledge in real world applications, etc.	Mathematics knowledge is mostly unrelated to everyday knowledge. For example, only very superficial references are made to related everyday knowledge.	Mathematics knowledge is always unrelated to everyday knowledge. For example, no references are made even to related everyday knowledge.
Degree to which the boundary between Mathematics discourse and the discourse of other subjects is distinct or 'blurred'				
2. INTER-DISCIPLINARY RELATIONS - MATHEMATICS AND OTHER SCHOOL SUBJECTS OR LEARNING AREAS	Mathematics knowledge is always integrated with other school subjects through themes.	Mathematics knowledge is mostly integrated with other school subjects through themes.	Knowledge of other school subjects is mostly separate from Mathematics knowledge.	Knowledge of other school subjects is always separate from Mathematics knowledge.
FRAMING - CONTROL	ALWAYS F- (4)	MOSTLY F- (3)	MOSTLY F+ (2)	ALWAYS F++ (1)
Discursive rules				
Degree to which the teacher or learners appear to have control over micro-selection				
7. THE SELECTION RULE	Learners always <i>appear</i> to determine the selection of activities, materials, or contents. For example, learners always have a choice of activities, materials and contents.	Learners mostly <i>appear</i> to determine the selection of activities, materials, or contents.	The teacher mostly determines the selection of activities, materials, or contents.	The teacher always determines the selection of activities, materials, or contents. For example, learners always have no influence over activities, materials and contents.
Degree to which the teacher or learners appear to have control over micro-sequencing				
8. THE SEQUENCING RULE	Learners always <i>appear</i> to determine sequencing or ordering of activities, materials or contents. For example, learners can always cover activities or contents or use materials in an optional order.	Learners mostly <i>appear</i> to determine sequencing or ordering of activities, materials or contents.	The teacher mostly determines sequencing or ordering of activities, materials or contents.	The teacher always determines sequencing or ordering of activities, materials or contents. For example, learners always have to cover activities or contents or use materials in a set order.
Degree to which the teacher or the learners appear to have control over micro-pacing				
9. THE PACING RULE	Learners always <i>appear</i> to determine the pace or amount of time spent on the contents, activities or materials. For example, the teacher never explicitly sets time limits or pressures learners.	Learners mostly <i>appear</i> to determine the pace or amount of time spent on the contents, activities or materials.	The teacher mostly determine the pace or amount of time spent on the contents, activities or materials.	The teacher always determines the pace or amount of time spent on the contents, activities or materials. For example, the teacher always sets time limits or pressures learners to work <i>pace</i> .

FRAMING – CONTROL	ALWAYS F– (4)	MOSTLY F– (3)	MOSTLY F+ (2)	MOSTLY F++ (1)
Instructional context cont.				
Discursive rules				
Evaluation Criteria				
Degree to which the criteria for evaluating texts are implicit or explicit				
10. RECOGNITION RULE	The required maths procedures/principles underlying tasks or activities are always implicit <i>a priori</i> .	The required maths procedures/principles underlying tasks or activities are mostly implicit <i>a priori</i> .	The teacher mostly provides learners with explicit and detailed demonstrations, illustrations or examples of the required mathematical procedures/principles <i>a priori</i> .	The teacher always provides learners with explicit and detailed demonstrations, illustrations or examples of the required mathematical procedure/principles <i>a priori</i> .
Degree to which the criteria for evaluating texts are implicit or explicit				
11. REALISATION RULE	The teacher always treats learners' efforts or answers as equally valuable but indicates to learners when their efforts or answers are more relevant, appropriate, valid or correct. For example, by never explicitly judging them as incorrect.	The teacher mostly treats learners' efforts or answers as equally valuable but indicates to learners when their efforts or answers are more relevant, appropriate, valid or correct. For example, by only occasionally explicitly judging them as incorrect.	The teacher mostly explicitly judges learners' efforts or answers as incorrect and mostly points out what is missing from irrelevant, inappropriate or incorrect answers.	The teacher always explicitly judges learners' efforts or answers as incorrect and always points out what is missing from irrelevant, inappropriate or incorrect answers.
Relational context				
CLASSIFICATION-POWER	ALWAYS C– (4)	MOSTLY C– (3)	MOSTLY C+ (2)	ALWAYS C++ (1)
RELATIONS BETWEEN SUBJECTS/AGENTS				
Degree to which the hierarchical relationship between the teacher and learners is 'masked' or clear				
3. TEACHER-LEARNER RELATIONS	The teacher's status, authority or power is always overt. Learners appear to be self-regulating and to take personal responsibility for initiating actions and following routines themselves.	The teacher's status, authority or power is mostly overt. Learners mostly appear to be self-regulating and to take personal responsibility for initiating actions and following routines themselves.	The teacher's status, authority or power is mostly overt. The teacher mostly regulates learners' actions and asserts her/his position of authority by making sure that learners focus attention on him/her and wait for his/her instructions or directions before acting.	The teacher's status, authority or power is always overt and unambiguous. The teacher always regulates learners' actions and asserts her/his position of authority by making sure that learners focus attention on him/her and wait for his/her instructions or directions before acting.
Degree to which hierarchies between learners are 'masked' or clear				
4. LEARNER-LEARNER RELATIONS	Learner's status as mathematics learners is based on shared competences established through equal participation in joint productions and/or equal inter-personal intervention/mediation from the teacher.	Learner's status as mathematics learners is mostly based on shared competences established through equal participation in joint productions and/or equal inter-personal intervention/mediation from the teacher.	Learner's status as mathematics learners is mostly based on private performances used to differentiate learners in terms of those who are able to respond successfully and those who are not.	Learner's status as mathematics learners is always based on private performances used to differentiate learners in terms of those who are able to respond successfully and those who are not.

Regulative context cont.				
CLASSIFICATION – POWER	ALWAYS C- (-4)	MOSTLY C- (3)	MOSTLY C+ (2)	ALWAYS C+ (+1)
RELATIONS BETWEEN SPACES				
Degree to which the boundary between the teacher's and the learners' space is distinct or blurred.				
5. RELATIONS BETWEEN SPACE FOR TEACHING AND SPACE FOR LEARNING	The teacher and learners always share space with each other. For example, learners continually move in the teacher's space to 'display' their answers and/or the teacher spends all or almost all the time in the learners' space monitoring learners' progress.	The teacher and learners mostly share space with each other.	The teacher and learners mostly remain in their own spaces. For example, they sometime share or move into each others' space.	The teacher and learners always remain in their own spaces. For example, learners never or hardly ever enter the teacher's space to 'display' their answers on the board and/or the teacher always or almost always spends time in his/her space teaching.
Degree to which the boundary between learners' space is distinct or blurred.				
6. INSULATION BETWEEN LEARNERS' SPACES	Learners are always seated in a shared space. For example, learners are seated at desks or tables clustered together.	Learners are mostly seated in a shared space but are sometimes seated in their own space.	Learners are mostly seated in their own space but are sometimes seated in a shared space.	Learners are always seated in their own space. For example, learners are seated individually at desks in rows or in pairs at two-seater desks and have their own material.
FRAMING – CONTROL	ALWAYS C- (-4)	MOSTLY C- (3)	MOSTLY C+ (2)	ALWAYS C+ (+1)
HIERARCHICAL RULES				
Degree to which communication relations between the teacher and learners are opened or closed.				
12. COMMUNICATION RELATIONS BETWEEN THE TEACHER AND THE LEARNERS	Learners always appear to share control with the teacher over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	Learners mostly appear to share control with the teacher over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	The teacher mostly has explicit control over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.	The teacher always has explicit control over who initiates or participates in communications with the teacher and over the timing, content and duration of teacher-learner interactions.
Degree to which communication relations between learners are opened or closed.				
13. COMMUNICATION RELATIONS BETWEEN LEARNERS	Learner-learner interaction is always promoted. For example, learners are always expected to work in collaboration with each other.	Learner-learner interaction is mostly promoted. For example, learners are mostly expected to work in collaboration with each other.	Learner-learner interaction is mostly discouraged. For example, learners are mostly expected to work without communicating with their peers.	Learner-learner interaction is always discouraged. For example, learners are always expected to work without communicating with their peers.

SECTION 2: OPPORTUNITY-TO LEARN

LEVELS OF COGNITIVE DEMAND

COGNITIVE DEMAND					
CONTENT LEVEL	The content is mostly higher than the Intermediate Phase level	The content is mostly at the grade 6 level	The content is mostly at the grade 5 level	The content is mostly at the grade 4 level	The content is mostly below the Intermediate Phase level
COGNITIVE LEVELS	The levels of cognitive demand in the lesson require <i>principled</i> and <i>procedural</i> mathematics knowledge. Learners are engaged with Maths procedures and to a larger extent with principles	The levels of cognitive demand in the lesson require <i>procedural</i> and <i>some</i> principled knowledge of mathematics. Learners are engaged with Maths procedures and to some extent with knowledge principles.	The levels of cognitive demand in the lesson require <i>procedural</i> knowledge of mathematics. Learners are engaged with routine Maths procedures.	The levels of cognitive demand in the lesson require <i>conceptual</i> knowledge of mathematics that never 'evolves' into procedural knowledge. Learners are engaged at conceptual levels only and do not progress to engagement with Maths procedures.	There are no or very low levels of cognitive demand. Learners are engaged with very low levels of skills or tasks such as drawing or colouring in which do not require the use of maths knowledge.
TIME-ON-TASK	All or most learners appear to be on-task and engaged in mathematics work during the lesson.			A number of learners appear to be off-task and disengaged with mathematics work during the lesson	
WORD PROBLEMS	There are real world applications of mathematical knowledge in word problems.			There are no real world applications of mathematical knowledge in word problems.	

LESSON OBSERVATION SCHEDULE: PART 2 - TERMS 1/ 2/ 3

School:		School number:	
Teacher's name:		Teacher's number:	
Grade 6 _____ LOLT:		Duration of observation: min	
Rater:		Date:	
SECTION 1: TYPE OF PEDAGOGY			
CLASSIFICATION – POWER	C- (4)	C- (3)	C- (2)
Instructional context			
Relations between discourses: INTER-DISCURSIVE RELATIONSHIPS			
Degree to which the boundary between Mathematics knowledge and 'everyday' knowledge is distinct or 'blurred'.			
1. RELATIONS BETWEEN MATHEMATICS AND EVERYDAY KNOWLEDGE			
Degree to which the boundary between Mathematics discourse and the discourse of other school subject is distinct or 'blurred'			
2. RELATIONS BETWEEN MATHEMATICS AND OTHER SCHOOL SUBJECTS OR LEARNING AREAS			
FRAMING – CONTROL	F- (4)	F- (3)	F- (2)
Discursive rules			
Degree to which the teacher or learners appear to have control over micro selection:			
7. SELECTION RULE			
Degree to which the teacher or learners appear to have control over micro sequencing:			
8. SEQUENCING RULE			
Degree to which the teacher or learners appear to have control over micro pacing:			
9. PACING RULE			
Evaluation criteria			
Degree to which the criteria for evaluation are implicit or explicit a priori:			
10. RECOGNITION RULE			
Degree to which the criteria for evaluating texts are implicit or explicit:			
11. REALISATION RULE			

Regulative context				
RELATIONS BETWEEN SUBJECTS/AGENTS				
CLASSIFICATION	C ₁ - (4)	C ₂ - (3)	C ₃ - (2)	C ₄ + (1)
POWER				
Degree to which the hierarchical relationship between the teacher and learners is 'masked' or clear.				
3. HIERARCHICAL RELATIONS BETWEEN THE TEACHER AND LEARNERS				
Degree to which hierarchies between learners are 'masked' or clear.				
4. HIERARCHICAL RELATIONS BETWEEN INDIVIDUAL LEARNERS				
RELATIONS BETWEEN SPACES				
Degree to which the boundary between the teacher's and learners' space is distinct or blurred.				
5. RELATIONS BETWEEN SPACE FOR TEACHING AND SPACE FOR LEARNING				
Degree to which the boundary between learners' spaces is distinct or blurred.				
6. INSULATION BETWEEN LEARNERS' SPACES				
FRAMING	F ₁ - (4)	F ₂ - (3)	F ₃ - (2)	F ₄ - (1)
CONTROL				
HIERARCHICAL RULES				
Degree to which communication relations between the teacher and learners are opened or closed.				
12. COMMUNICATION RELATIONS BETWEEN THE TEACHER AND THE LEARNERS				
Degree to which the communication relations between learners are opened or closed.				
13. COMMUNICATION RELATIONS BETWEEN LEARNERS				
SECTION 2: OPPORTUNITY-TO-LEARN				
COGNITIVE DEMAND				
	1	2	3	5
CONTENT LEVEL				
COGNITIVE LEVEL				
TIME-ON-TASK				
WORD PROBLEM				

APPENDIX 11:

Learner Questionnaire

Name: Age: years

Name of your Grade 6 Mathematics Teacher:

Name of School:

Language in which the test was written: English or Afrikaans

OPPORTUNITY-TO-LEARN GRADE 6 MATHEMATICS LEARNER QUESTIONNAIRE

GENERAL DIRECTIONS

In this questionnaire we are going to ask you questions about yourself. The information you give us will be kept confidential. We will not show your answers to any teachers at your school.

Some of the questions will be followed by a few possible choices indicated with a letter next to or below it. For these questions, circle the letter next to or below your choice as shown in Example 1.

Example 1

	Yes	No
1. I attend school	<input checked="" type="radio"/> A	<input type="radio"/> B

The letter "A" has been circled because you attend school.

If you decide to change your answer to a question put an "X" over your first choice and then put a circle around your new choice as shown in Example 2.

Example 2

	Yes	No
1. I like ice cream	<input checked="" type="radio"/> A	<input checked="" type="radio"/> B

For other questions you will be asked to write a number or date in the space provided. For these questions, you may use words and numbers in your answers. When you write, please be sure that your handwriting is clear.

We will read each question carefully together. Please answer as accurately and carefully as possible. You may ask for help if you do not understand something, or are unsure how to answer.

1. On what date were you born?

Write in the day, month and year if you know them.

_____ day _____ month _____ year

2. Are you a girl or a boy?

Circle either A or B.

Girl A

Boy B

The next questions ask about the people you live with. If you live at more than one place, please give answers about the place that is your home most of the time.

3. Does your MOTHER live at home with you most of the time?

Circle either A or B.

Yes A

No B

4. Does your FATHER live at home with you most of the time?

Circle either A or B.

Yes A

No B

5. Which person takes care of you everyday at home most of the time?

Circle just one letter: A, B, C, D, E, F, G or H.

Mother A

Father B

Grandparent C

Brother D

Sister E

Another relative (uncle, aunt, cousin, etc.) F

Another person (not blood relative) G

Nobody (I take care of myself) H

6. Did your MOTHER or the person who mainly takes care of you at home finish high school?

Circle just one letter: A, B or C.

Yes A

No B

I don't know C

7. Did your MOTHER or the person who mainly takes care of you at home study further at a college or university after high school?

Circle just one letter: A, B or C.

Yes A

No B

I don't know C

8. How often do you speak English with your family at home?

Circle just one letter: A, B or C.

- I speak English all the time or nearly all the time at home A
I speak English about half the time at home B
I speak another language all the time or nearly all the time at home C

9. How often do you speak Afrikaans with your family at home?

Circle just one letter: A, B or C.

- I speak Afrikaans all the time or nearly all the time at home A
I speak Afrikaans about half the time at home B
I speak another language all the time or nearly all the time at home C

10. What type of building do you live in?

Circle just one letter: A, B or C.

- Informal shack or hut A
Wooden wendy house B
Brick or stone building C

11. Does your house have any of the following

Circle either A or B for each line.

- | | Yes | No |
|---------------------------|-----|----|
| Electricity | A | B |
| Running tap water | A | B |
| Hot running water | A | B |
| Water flushed toilet..... | A | B |

12. How safe from crime and violence is the area where you live?

Circle just one letter: A or B.

- Somewhat safe..... A
Very unsafe B

13. Is there always a quiet room at home where you can study or do your homework whenever you want?

Circle either A or B.

- Yes A
No B

14. Is there always a desk or table at home where you can study or do your homework whenever you want?

Circle either A or B.

- Yes A
No B

15. How many books are there in your home? (Do NOT count magazines, newspapers and school books)

Circle just one letter: A, B or C.

- Less than a full bookshelf (0 to 25 books)..... A
One or several bookshelves (26 – 100 books)..... B
One or more bookshelves full (over 100 books)..... C

16. Do YOU have the use of a computer at home?

Circle either A or B.

Yes A

No B

17. In total, how many years have you lived in your present neighbourhood or area?

Write in the total number. If you don't know, just write 'Don't know'.

_____ years _____

18. How far does your family expect you to study in school or after school?

Circle just one letter: A, B, C, D, E or F.

My family expects me to finish primary school and then leave school A

My family expects that I won't finish high school B

My family expects me to finish high school but not to study further C

My family expects me to study at a college after high school D

My family expects me to study at university after high school E

I don't know how far my family expects me to study F

19. If you need help with your school work or homework, about how many people at home or outside of school do you feel that you can call on for help (for example, your parents, other members of your family or adult friends)?

Write in the total number of people. If there is no one, just write 0.

20. How often does an adult person at home talk to you about things you have studied in school or help you with your homework?

Circle just one letter: A, B, C or D.

Never A

Sometimes B

Very often (almost every day) C

I don't ever do school work at home D

21. During this school year, have your parents or the person who mainly takes care of you at home attended a meeting at your school?

Circle just one letter: A, B or C.

Yes A

No B

I don't know C

22. How well do your parents or the person who mainly takes care of you at home know your friends?

Circle just one letter: A, B or C.

They don't know my friends at all A

They know just a little about my friends B

They know my friends well C

23. How often does your MOTHER or the person who mainly takes care of you at home get together with other people outside your family to do or talk about things (for example, to sing in a church choir or to discuss community problems)?

Circle just one letter: A, B, C or D.

Often A
Sometimes B
Never C
I don't know D

24. Outside of school do you ever have extra Mathematics lessons with another teacher who is not from your school?

Circle either A or B.

Yes A
No B

THANK YOU for answering these questions. We wish you well in the future.

APPENDIX 12:

Descriptive data on Grade 6 mathematics
curriculum coverage and emphasis

OPPORTUNITY-TO-LEARN

GRADE 6 MATHEMATICS

Descriptive data: Curriculum Coverage and emphasis

First Three Terms 2003

Indicating

- a) the percentage of learners that covered each subtopic in the first three terms of 2003.
- b) the estimated average number of lessons spent on each topic covered.

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

L1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS

% of learners that covered

Ideal time for Grade 6 content

Estimated average number of lessons spent on content

Number of single 30 min periods

Less than one

If one or more, estimated average no. single periods

Counting including:

Counting forwards and backwards in

1	• 2s (g4,5)	82		X	
2	• 3s (g4,5)	76		X	
3	• 5s (g4,5)	76		X	
4	• 10s (g4,5)	79			1
5	• 25s (g4,5)	71			1
6	• 50s (g4,5)	68			1
7	• 100s (g4,5)	74			1
8	• a variety of whole number intervals between 0 and 10 000 (g4,5)	50			1
9	• fractions (g5)	45			2
	• decimals (g6)	26	2-4		2

Representing and comparing whole numbers including zero and fractions including:

Whole numbers to

11	• 4-digit numbers (g4)	84			3
12	• 6-digit numbers (g5)	76			3
	• 9-digit numbers (g6)	21	4-6	X	
14	Odd and even number to 1 000 (g4)	32		X	
15	Common fractions in discriminative form (g4)	50			4

Common fractions with different denominators including

16	• halves (g4)	84			1
17	• thirds (g4)	82			1
18	• quarters (g4)	82			1
19	• fifths (g4)	79			1
20	• sixths (g4)	79			1
21	• sevenths (g4)	74			1
22	• eighths (g4)	76			1
	• tenths (g5, 6)	71	4		1
	• twelfths (g5, 6)	50			1
	• hundreds (g6)	24	2-4		1
	Common fractions including percentages (g6)	13	2		1

Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement (g4,5)

27	Decimal fractions to at least two decimal places (g5)	37			2
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1 in terms of its multiplicative property [When a number is multiplied by its multiplicative inverse the answer is 1] (g5,6)

		26	1		1
30	Factors of any 2-digit whole number (g5)	58			2
31	Multiples of single-digit numbers to 100 (g4,5)	68			2
	Multiples of any 2-digit whole number (g6)	53	2-4		2
	Multiples of any 3-digit whole number (g6)	32	2-4		1
	Prime numbers to 100 (g6)	29	3		2

Place value of digits in whole numbers to:

35	• 4-digit numbers (g4)	84			4
36	• 6-digit numbers (g5)	71			4
	• 9-digit numbers (g6)	76	4-6		1

Equivalent forms of the rational numbers including:

38	Common fractions with denominators that are multiples of each other (g4,5)	58			3
	Common fractions with 1-digit or 2-digit denominators (g6)	53	4-8		4

			Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
		% of learners that covered	Number of single 30 min periods	Less than one	If one or more, estimated average no. single periods
Equivalent forms of the rational numbers including: (CONTD)					
40	Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement (4.5)	31			2
	Decimal fractions to 2 decimal places (4.6)	47	4		3
	Percentages (4.6)	16	2		2
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS					
Solving problems in different contexts such as:					
43	Financial (e.g. buying and selling; profit and loss; simple budgets) (4.5)	42			2
	Financial (e.g. reading and interpreting accounts, discount) (4.6)	13	6		2
	Measurements in Natural Science and Technology contexts (4.5,6)	8	1-2		1
Solving problems that involve comparing:					
	• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2,5m to 1,5m = 5:3 or 5/3) (4.5,6)	8	3		1
	• two quantities of different kinds by division (i.e. rate e.g. kg/R, learners/teacher, km/hr; wages/day) (4.5,6)	8	6		2
Using operations appropriate to solving problems involving:					
Rounding off to the nearest					
	• 10 (4.5,6)	82	2-4		2
	• 100 (4.5,6)	74	2-4		2
	• 1 000 (4.5,6)	68	2-4		2
	• 5 (4.5,6)	13	2-4		1
Addition and subtraction of whole numbers with					
52	• 4 digits (4)	92			5
	• 5 digits (4.5,6)	79	8		5
54	Addition of common fractions in context (4)	53			3
56	Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers) (4.5)	55	8-4		6
Multiplication of					
57	• whole 2-digit by 2-digit numbers (4.7)	87			4
58	• whole 3-digit by 2-digit numbers (5)	79			4
	• whole 4-digit by 3-digit numbers (4.6)	32	6		2
Division of					
60	• whole 3-digit by 1-digit whole numbers (4)	82			4
61	• whole 3-digit by 2-digit whole numbers (4.5)	71			3
	• whole 4-digit by 3-digit whole numbers (4.6)	18	2-4		2
63	Equal sharing with remainders (4)	26			3
	Finding fractions of whole numbers which result in whole numbers (4.5,6)	85	4		5
	Equivalent fractions (4.5,6)	66	4		4
	Addition and subtraction of positive decimals with 2 decimal places (4.5)	53	4		4

		Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
	% of learners that covered	Number of single 30 min periods	Less than one	If one or more, estimated average no. single periods
Using operations appropriate to solving problems involving: (CONTD)				
Finding percentages of whole numbers (g6)	5	2		5
Multiple operations on whole numbers with or without brackets (g6)	37	4		3
1.3 CALCULATION TYPES INVOLVING NUMBERS				
Mental calculations involving:				
Addition (g4,5,6)	90	5		3
Subtraction (g4,5,6)	82	5		3
Multiplication of whole numbers up to				
• 10 x 10 (g4,5)	71			2
• 12 x 12 (g6)	33	2-4		2
Written and mental calculations with whole numbers involving:				
Adding and subtracting columns (g5, 6)	79	6		6
Multiplying in columns (g6)	68	6		4
Long division (g6)	61	8		4
Building up and breaking down numbers (g4,5,6)	50			3
Rounding off and compensating (g4,5,6)	26			3
Doubling and halving (g4 & 5)	29			2
Using a number line (g4)	37			3
Using a calculator (g4,5,6)	42	4		2
Using a range of strategies to check solutions and judge the reasonableness of solutions (g4,5,6)	37	6		1
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS				
The reciprocal relationship between multiplication and division, e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$ (g4,5)	29			2
The equivalence of division and fractions e.g. $1 \div 8 = 1/8$ (g4,5)	13			1
Divisibility rules for				
• 2 (g6)	24	1		1
• 5 (g6)	24	1		1
• 10 (g6)	26	1		1
• 100 (g6)	18	2		1
• 1 000 (g6)	11	2		2
The commutative properties with whole numbers [for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$], for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$)] (without learners necessarily teaching the term 'commutative') (g5,6)	21	4-6		1
The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c - e.g. $(12 + 2) + 8 = 12 + (2 + 8)$], for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c - e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term 'associative') (g5,6)	11	4-6		
The distributive properties with whole numbers [for multiplication over addition: $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c - e.g. $5 \times (3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term 'distributive') (g5,6)	11	3-5	1	

SECTION 2: MEASUREMENT

		Ideal time for Grade 6 content	Estimated average number of lessons spent on content
	% of learners that covered	Number of single 30 min periods	If one or more, estimated average no single periods

2.1 TIME

Reading and writing analogue, digital and 24-hour time including:

Analogue time (time read from a clock with a face and hands)

• to the nearest minute (g4,5,6)	24		2
• to the nearest second (g4,5,6)	16		1

Digital time (time read from a clock that has a continually changing digit display rather than a clock face)

• to the nearest minute (g4,5,6)	18		2
• to the nearest second (g4,5,6)	13		1

24-hour time

• to the nearest minute (g4,5,6)	26	2	2
• to the nearest second (g4,5,6)	16	2	2

Solving problems involving calculation and conversions between appropriate time units including:

• seconds (g4)	40		X
• minutes (g4)	30		1
• hours (g4)	30		1
• days (g4)	48		1
• weeks (g4)	42		1
• months (g4)	45		1
• years (g4)	47		1
• decades (g5)	21		1
• centuries (g5)	21		1
• millennia (g5)	13		1
• time zones and differences (g6)	8	2-4	2

Using time-measuring instruments with precision (accuracy) including:

• clocks (g4)	11		1
• watches (g4,5)	11		1
• stopwatches (g5)	0		0

2.2 UNITS AND INSTRUMENTS

2.2.1 MASS, CAPACITY AND LENGTH

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units (System International (d'Unités): the universally-used system of scientific units) with appropriate precision (accuracy) for:

• Mass using kilograms (kg) (g4,5,6)	53	2	2
• Mass using grams (g) (g4,5,6)	53	2	2
• Capacity using litres (l) (g4,5,6)	47	2	1
• Capacity using millilitres (ml) (g4,5,6)	47	2	1
• Length using metres (m) (g4,5,6)	53	2	1
• Length using centimetres (cm) (g4,5,6)	53	2	1
• Length using millimetres (mm) (g4,5,6)	53	2	1
• Length using kilometres (km) (g4,5,6)	47	2	1
• Temperature using degree Celsius scale (g5,6)	5	2	2

Using measuring instruments for measuring:

Mass			
• Using bathroom scales (g4,5,6)	5	2-4	2
• Using kitchen scales (g4,5,6)	5		2
• Using balances (g4,5,6)	5		1
Capacity			
• Using measuring jugs (g4,5,6)	5	2-4	1
Length			
• Using rulers (g4,5,6)	8	2	1
• Using meter sticks (g4,5,6)	18		1
• Using tape measures (g4,5,6)	16		1
• Using trundle wheels (g4,5,6)	8		1

		Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
	% of learners that covered	Number of single 30 min periods	Less than one	If one or more, estimated average no. single periods
Temperature:				
• Using thermometers (g5,6)	3	1		1
2.2.2 PERIMETER, AREA, VOLUME				
Measuring and approximating including:				
Perimeter:				
• Using rulers (g4,5 & 6)	16	2		2
• Using measuring tapes (g4,5,6)	5			1
Perimeter:				
• polygons (using square grids and tiling) to develop understanding of square units (g4,5)	3	6		2
• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles (g6)	3			2
• circles (g6)	0			0
• squares (g6)	16			1
• rectangles (g6)	18			2
Volume/capacity of:				
• 3-D objects (by packing or filling them) to develop rules an understanding of cubic units (g4,5)	0			0
• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms (g6)	0	2		0
Investigation relationships between				
• the perimeter and area of rectangles (g6)	16	2		3
• the perimeter and area of squares (g6)	13			3
• surface area, volume and the dimensions of rectangular prisms (g6)	0	4		0
Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:				
• Right angles (g5,6)	26	4		2
• Angles smaller than right angles (g5,6)	26			2
• Angles greater than right angles (g5,6)	26			2
SECTION 3 : SPACE AND SHAPE (GEOMETRY):				
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:				
• Rectangular prisms (g4)	21			1
• Spheres (g4)	5			2
• Cylinders (g4)	8			1
• Prisms and pyramids (g4)	8			1
• Circles (g4)	21			2
• Rectangles (g4)	21			2
• Polygons in terms of the number of sides up to 8 sided figures (g4)	21			2
• Other objects (g4)	5			2
Recognising and naming similarities and differences between:				
• squares and rectangles (g5)	18			1
• cubes and rectangular prisms (g5)	11			1
• tetrahedrons (a polyhedron with four faces) and other pyramids (g6)	3	2		1
• rectangles and parallelograms (g6)	11	2		1
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:				
• Shapes of faces (g4,5,6)	18	2		1
• Number of sides (g4,5,6)	21			1
• Number of faces (g5,6)	16			1

		Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
			Less than one	If one or more, estimated average no. single periods
	Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to: (CONTD)			
160	• Flat and curved surfaces/straight and curved sides (g4)	5		1
	• Edges (where two faces of a solid object meet) (g6)	5	2	1
	• Vertices (the point where the arms of an angle meet; the point where edges of a polyhedron meet; the apex of a cone) (g6)	5	1	1
	• Lengths of sides (g5 & 6)	13	1	2
	• Angle size of corners (g6)	13	1	2
	Making 2-D and 3-D models			
165	• of geometric objects using cut out polygons (g4,5)	3		2
166	• of geometric objects (example boxes) to trace nets (g5)	0		0
	• by drawing shapes on grid paper (g4,5,6)	8	2	2
	• using drinking straws to make a skeleton (g6)	3	2	2
	• using nets (a flat diagram from which a model of a polyhedron can be made) (g6)	0	2	0
	• using a pair of compasses to draw circles, patterns in circles and patterns with circles (g6)	0	4	0
	3.2 TRANSFORMATIONS			
171	Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms (g4)	3		1
	Using geometric figures and solids to recognise, describe and perform:			
172	• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position) (g5)	3		1
173	• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed) (g5)	5		1
174	• Translations (slides – a transformation under which a shape or object is moved by sliding into a new position) (g5)	3		1
	Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry) (g6)	3	4	1
	Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:			
176	• Tessellations (tiling – formed by fitting shapes together to cover a plane without overlapping or leaving gaps) (g4,5)	5		2
177	• Line symmetry (g4,5)	11		1
178	• Rotational symmetry (g5)	3		1
179	• Movement including rotations, reflections and translations (g5)	3		1
	• Geometric properties (g4,5,6)	0	2	0

	Ideal time for Grade 6 content	Estimated average number of lessons spent on content	If one or more, estimated average no. single periods
	% of learners that covered	Number of single 30 min periods	Less than one
181 Drawing enlargements and reductions of 2-D shapes (at least quadrilaterals and triangles) using grid paper to compare their size and shape (g6)	0	2-4	0
3.3 POSITION			
182 Describing changes in the view of an object held in different positions (g4)	3		1
183 Describing views of a simple 3-D object from different positions (perspectives) (g5)	3		1
184 Making sketches of a simple 3-D object from different positions (perspectives) (g6)	3	2	1
Locating position on a coded (labelled) grid including maps:			
185 • from given instructions by column and row (g4)	0		0
• by tracing paths between positions following verbal and written instructions (g5,6)	3		1
Recognising maps as grids (g6)	0	2	0
SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA:			
4.1 PATTERNS			
Investigating and extending numeric and geometric patterns:			
• Represented in physical or diagrammatic form (g4,5,6)	35	4	3
• Not limited to sequences involving constant difference or ratio (g4,5,6)	11	4	2
• Found in natural and cultural contexts (g4,5,6)	11		1
• Of the learner's own creation (g4,5,6)	11		1
• Represented in tables (g6)	11	4	1
Describing observed relationships or rules of numeric and geometric patterns (g4,5,6)	3	4	4
4.2 EQUATIONS			
Determining output value for given input values using:			
• Verbal descriptions (g4,5,6)	3		3
• Flow diagrams (a diagram which shows the steps to be followed in solving a problem) (g4,5,6)	6		0
• Tables (g6)	0		0
Writing number sentences describing a problem situation including problems within contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues (g4,5,6)	3		1
Solving or completing open number sentences by inspection or by trial-and-improvement, checking the solutions by substitution, e.g. $\square + 4 = 12$ or $2 \times \square - 8 = 0$ (g5,6)	11	6	1
4.3 EQUIVALENT REPRESENTATIONS			
Determining the equivalence of different descriptions of the same relationship or rule presented:			
• Verbally (g4,5,6)	0		0
• In flow diagrams (g4,5,6)	3		1
• By number sentences (g4,5,6)	3		1
• In tables (g6)	6	3	6

SECTION 5: DATA HANDLING:

5.1 COLLECTING AND ORGANISING DATA	% of learners that covered	Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
		Number of single 30 min periods	Less than one	If one or more, estimated average no. single periods
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment (g4, 5, 6)	34			3
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners (g5,6)	29			4
Using tallies and tables to organise and record data (g5,6)	32	4		3
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
<ul style="list-style-type: none"> the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies (g4, 5, 6) 	16	1		3
<ul style="list-style-type: none"> the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies (g5,6) 	8	1		2
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
<ul style="list-style-type: none"> Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g4) 	21			2
<ul style="list-style-type: none"> Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g5, 6) 	8			3
<ul style="list-style-type: none"> Bar graphs (uses vertical or horizontal bars to represent information) (g4,5,6) 	58			4
<ul style="list-style-type: none"> Double bar graphs (g6) 	0	2-4		0
Reading and interpreting data presented in a variety of ways (including own representations and representations in the media – both words and graphs) to draw conclusions and make predictions sensitive to the role of:				
<ul style="list-style-type: none"> Context (e.g. rural or urban, national or provincial) (g4,5,6) 	11			2
<ul style="list-style-type: none"> Categories within the data (e.g. age, gender and race) (g5,6) 	11			2
<ul style="list-style-type: none"> Other human rights issues (g4,5,6) 	3	4		2
5.3 CHANCE				
Comparing, classifying and ordering events from daily life on a scale from certain that they will happen to certain that they will not happen (g4,5)	3			2
Predicting the likelihood of events in daily life based on observation and placing them on a scale from impossible to certain (g6)	0	2		0

	% of learners that covered	Ideal time for Grade 6 content	Estimated average number of lessons spent on content	
		Number of single 30 min periods	Less than one	If one or more, estimated average no. single periods
Listing possible outcomes for simple experiments including:				
• tossing a coin (g5,6)	0	4	3	0
• rolling a die (g5,6)	3			
• spinning a spinner (g5,6)	0			0
Counting:				
• the number of possible outcomes for sample trails (g4)	0			0
• the frequency of actual outcomes for a series of trials (g5,6)	0	4		0

APPENDIX 13:

The mathematics curriculum
generally made available to grade 6 learners

The curriculum generally made available to grade 6 learners by the end of the third term 2003 (i.e. at least 50% of learners covered this content)

Shading indicates that the content reflects grade 6 level expectations.

LO 1: NUMBER, OPERATION AND RELATIONSHIPS

Recognising, classifying and representing numbers

Counting backwards and forwards in 2s, 3s, 5s (on average less than 1 lesson), 10s, 25s, 50s, 100s – a variety of whole number intervals between 0 and 10 000 (on average 1 lesson on each – all grade 4, 5 level)

Representing and comparing whole numbers to 4 digit numbers (on average 3 lessons – grade 4 level) and 6 digit numbers (on average 3 lessons – grade 5 level)

Representing and comparing common fractions in diagrammatic form (on average 4 lessons – grade 4 level)

Representing and comparing common fractions with different denominators including halves, thirds, quarters, fifths, sixths, sevenths, eighths (on average 1 lesson on each (7) – grade 4 level), tenths, twelfths (on average 1 lesson on each (2) – grade 5, 6 level)

Representing and comparing decimal fractions to at least two decimal places (on average 4 lessons – grade 6 level)

Representing and comparing factors of any 2-digit whole numbers (on average less than 2 lesson – grade 5 level)

Representing and comparing multiples of single digit numbers to 100 (on average 2 lessons – grade 4, 5 level) **and any 2- digit whole number (on average 2 lessons – grade 6 level)**

Place values of digits in whole numbers from 4-digit numbers (on average 4 lessons – grade 4 level) to 6-digit numbers (on average 4 lessons – grade 4, 5 level)

Equivalent forms of rational numbers including common fractions with denominators that are multiples of each other (on average 3 lessons – grade 4, 5 level) and common fractions with 1-digit and 2-digit denominators (on average 4 lessons – grade 5 level)

Applications of numbers to problems

Using operations appropriate to solving problems involving rounding off the nearest 10, 100 (on average 2 lessons on each (4) and 1 000 (on average 2 lessons – all grade 4, 5, 6 level)

Using operations appropriate to solving problems involving addition and subtraction of whole numbers with 4 (on average 5 lessons – grade 4) **and 5-digit numbers (on average 5 lessons – grade 5, 6 level)**

Using operations appropriate to solving problems involving addition and subtraction of common fractions in context (on average 3 lessons – grade 4 level)

Using operations appropriate to solving problems involving addition and subtraction of common fractions with the same denominators and whole numbers with common fractions (mixed numbers) (on average 6 lessons – grade 5 level) **and involving addition and**

subtraction of common fractions with denominators that are multiples of each other and whole numbers with common fractions (mixed numbers) (on average 6 lessons – grade 6 level)

Using operations appropriate to solving problems involving multiplication of whole 2-digit by 2-digit numbers (on average 4 lessons) and whole 3-digit by 2-digit numbers (on average 4 lessons – grade 4, 5 level)

Using operations appropriate to solving problems involving division of 3-digit by 1-digit whole numbers (on average 4 lessons) and 3-digit by 2-digit whole numbers (on average 3 lessons – grade 4, 5 level)

Using operations appropriate to solving problems involving finding fractions of whole numbers which result in whole numbers (on average 5 lessons – grade 4, 5, 6 level)

Using operations appropriate to solving problems involving equivalent fractions (on average 4 lessons – grade 5, 6 level)

Using operations appropriate to solving problems involving addition and subtraction of positive decimals with 2 decimal places (on average 4 lessons – grade 6 level)

Calculation types involving numbers

Mental calculations involving addition and subtraction (on average 3 lessons on each (6) – grade 4, 5, 6 level)

Mental calculations involving multiplication of whole numbers up to 10×10 (on average 2 lessons – grade 4, 5 level) and 12×12 (on average 2 lessons – grade 6 level)

Written and mental calculations with whole numbers involving adding and subtracting in columns (on average 6 lessons – grade 5, 6 level)

Written and mental calculations with whole numbers involving multiplying in columns (on average 4 lessons – grade 6 level)

Written and mental calculations with whole numbers involving long division (on average 4 lessons – grade 6 level)

Written and mental calculations with whole numbers involving building up and breaking down numbers (on average 4 lessons – grade 4, 5, 6 level)

LO 4: MEASUREMENT

Time

Solving problems involving calculations and conversions between appropriate time units including minutes and hours (on average 1 lesson each (2) – grade 4 level)

Units and instruments

Mass, capacity and length

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units with appropriate precision for mass using kilograms and grams (on average 2 lessons each (4) – grade 4, 5, 6 level)

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units with appropriate precision for length using metres, centimetres and millimetres (on average 1 lesson each (3) – grade 4, 5, 6 level)

LO 2: PATTERNS, FUNCTIONS AND ALGEBRA

Patterns

Investigating and extending numeric and geometric patterns represented in physical and diagrammatic form (on average 3 lessons – grade 4, 5, 6 level)

LO 5: DATA HANDLING

Representing and interpreting data

Drawing graphs to display and interpret ungrouped data including bar graphs (using vertical or horizontal bars to represent information) (on average 4 lessons – grade 4, 5, 6 level)

APPENDIX 14:

Illustrative examples from field notes
for content by cognitive demand

Illustrative examples of extracts from field notes for content by cognitive demand

Low levels of cognitive engagement

The grade 6 learners were involved in two tasks during the lesson. One task entailed reciting multiplication tables (6 times tables and then seven times tables up to 6×10 and 7×10 and 2 times table up to 30). The other task comprised folding an A4 page into two equal parts as an introduction to fractions. The work covered was mostly at Foundation Phase level. Learners were engaged with a low level of conceptual understanding of fractions.

Engagement with principled and procedural mathematics knowledge

The lesson focused on the use of the decimal comma or decimals in measurement. The teacher started by saying (in Afrikaans) that the decimal comma was used in the 'prices' of goods and explained how 'R1=100 cents' which meant that '100 cents makes a whole (rand)'. She said, 'So if I have 5 cents – it is equal to what of a rand – it is part of a whole, in Maths we call it a "breuk." (Afrikaans for a fraction). 5 cents is a fraction of a rand. The whole is?' The class called out in unison, '100'. She wrote $R1 = 100/100$ and called a learner to the board to show that $5c = 5/100 = 0,05$ 'as a decimal'. She asked the class, 'Why 0,05?' A learner explained that the second place after the comma is the 'place of hundredths' and the discussion that followed dealt with the 'place' of 'tenths' and 'thousandths'. When she introduced measurement, she said, 'As we did with rand, we are looking at the decimal comma and place value in measurement.' The teacher made the underlying principles of decimal places and decimal fractions explicit by recruiting examples from 'money' and then 'measurement'. She constantly emphasized and illustrated the difference between tenths, hundredths and thousandths in terms of decimal place value.

APPENDIX 15:

Descriptive data on grade 5 mathematics
curriculum coverage and emphasis

OPPORTUNITY-TO-LEARN

GRADE 5 MATHEMATICS

Descriptive data: Curriculum Coverage and emphasis

FIRST THREE TERM 2003

First Three Terms 2003

Indicating

- a) the percentage of learners that covered each subtopic in the first three terms of 2003.
- b) the estimated average number of lessons spent on each topic covered.

SECTION 1 : NUMBER, OPERATION AND RELATIONSHIPS:

1.1 RECOGNISING, CLASSIFYING AND REPRESENTING NUMBERS	% of classes that covered	Estimated average number of lessons spent on content		Ideal number: single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
Counting including:				
Counting forwards and backwards in:				
• 2s (g4,5)	83		1	
• 3s (g4,5)	83		1	
• 5s (g4,5)	83		1	
• 10s (g4,5)	79		1	1
• 25s (g4,5)	54		1	1
• 50s (g4,5)	53		1	1
• 100s (g4,5)	58		1	1
• a variety of whole number intervals between 0 and 10 000 (g4,5)	46		2	1
• fractions (g5)	21		2	1
• decimals (g6)	8		2	
Representing and comparing whole numbers including zero and fractions including:				
Whole numbers to:				
• 4-digit numbers (g4)	88		3	
• 6-digit numbers (g5)	46		3	2
• 9-digit numbers (g6)	13		1	
Odd and even number to 1 000 (g4)	54		2	
Common fractions in diagrammatic form (g4)	58		2	
Common fractions with different denominators including:				
• halves (g4)	79		1	
• thirds (g4)	67		1	
• quarters (g4)	71		1	
• fifths (g4)	67		1	
• sixths (g4)	67		1	
• sevenths (g4)	54		1	
• eighths (g4)	67		1	
• tenths (g 5, 6)	50		1	
• twelfths (g5, 6)	42		1	4
• hundreds (g6)	25		1	
Common fractions including percentages (g6)	4		1	
Decimal fractions of the form 0.5, 1.5 and 2.5 etc. in the context of measurement (g4,5)	21		2	3
Decimal fractions to at least two decimal places (g6)	42		2	
1 in terms of its multiplicative property [When a number is multiplied by its multiplicative inverse the answer is 1] (g5,6)	33		2	
Factors of any 2-digit whole number (g5)	50		2	2-4
Multiples of single-digit numbers to 100 (g4,5)	58		4	4-6
Multiples of any 2-digit whole number (g6)	42		2	
Multiples of any 3-digit whole number (g6)	17		1	
Prime numbers to 100 (g6)	38			
Place value of digits in whole numbers to:				
• 4-digit numbers (g4)	92		6	
• 6-digit numbers (g5)	46		3	4
• 9-digit numbers (g6)	0		0	
Equivalent forms of the rational numbers including:				
Common fractions with denominators that are multiples of each other (g4,5)	63		3	6-12
Common fractions with 1-digit or 2-digit denominators (g6)	56		2	

	Estimated average number of lessons spent on content	If one or more, estimated average no. single periods	Ideal – number single 30 min periods
	% of classes that covered	Less than one	
Equivalent forms of the rational numbers including: (CONTD)			
Decimal fractions of the form 0.5; 1.5 and 2.5 etc. in the context of measurement (g4.5)	21	2	2
Decimal fractions to 2 decimal places (g6)	42	3	
Percentages (g6)	17	2	
1.2 APPLICATIONS OF NUMBERS TO PROBLEMS			
Solving problems in different contexts such as:			
Financial (e.g. buying and selling, profit and loss, simple budgets) (g4.5)	30	3	6
Financial (e.g. reading and interpreting accounts, discount) (g6)	17	3	
Measurements in Natural Science and Technology contexts (g4.5.6)	8	2	4
Solving problems that involve comparing:			
• two or more quantities of the same kind by division (i.e. ratio e.g. the ratio of 2.5m to 1.5m = 5:3 or 5/3) (g4.5.6)	8	2	1
• two quantities of different kinds by division (i.e. rate e.g. kg/l, learners/teacher, km/hr, wages/day) (g4.5.6)	13	2	6
Solving problems that involve comparing:			
Rounding off to the nearest			
• 10 (g4.5.6)	67	2	1
• 100 (g4.5.6)	57	2	1
• 1 000 (g4.5.6)	29	2	1
• 5 (g5.6)	4	1	1
Addition and subtraction of whole numbers with			
• 4 digits (g4)	68	5	
• 5 digits (g5.6)	58	4	6-8
Addition of common fractions in context (g4)	46	2	
Addition and subtraction of common fractions with the same denominator and whole numbers with common fractions (mixed numbers) (g5)	38	3	6-8
Addition and subtraction of common fractions with denominators which are multiples of each other and whole numbers with common fractions (mixed numbers) (g6)	33	3	
Multiplication of 3			
• whole 2-digit by 2-digit numbers (g4)	79	3	
• whole 3-digit by 2-digit numbers (g5)	67	3	6
• whole 4-digit by 3-digit numbers (g6)	21	2	
Division of			
• 3-digit by 1-digit numbers whole numbers (g4)	63	3	
• 3-digit by 2-digit whole numbers (g5)	25	2	6
• 4-digit by 3-digit whole numbers (g6)	13	1	
Equal sharing with remainders (g4)	42	3	
Finding fractions of whole numbers which result in whole numbers (g4.5.6)	42	3	8
Equivalent fractions (g5.6)	46	2	6-8
Addition and subtraction of positive decimals with 2 decimal places (g6)	42	3	

	% of classes that covered	Estimated average number of lessons spent on content		Ideal number: single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
Using operations appropriate to solving problems involving: (CONTD)				
Finding percentages of whole numbers (g6)	4	X		
Multiple operations on whole numbers with or without brackets (g6)	33		3	
1.3 CALCULATION TYPES INVOLVING NUMBERS				
Mental calculations involving:				
Addition (g4,5,6)	88		3	6
Subtraction (g4,5,6)	83		3	6
Multiplication of whole numbers up to				
• 10 x 10 (g4,5)	75		3	6
• 12 x 12 (g6)	50		2	
Written and mental calculations with whole numbers involving:				
Adding and subtracting columns (g5,6)	83		7	6
Multiplying in columns (g6)	50		5	
Long division (g6)	38		3	
Building up and breaking down numbers (g4,5,6)				
Rounding off and compensating (g4,5,6)	42		3	4
Doubling and halving (g4 & 5)	63		2	4
Using a number line (g4)	33		3	
Using a calculator (g4,5,6)	21		2	6
Using a range of strategies to check solutions and judge the reasonableness of solutions (g4,5,6)	38		3	4
1.4 RECOGNISING AND USING PROPERTIES OF NUMBERS				
The reciprocal relationship between multiplication and division, e.g. if $5 \times 3 = 15$, then $15 \div 3 = 5$ and $15 \div 5 = 3$ (g4,5)	33		3	4
The equivalence of division and fractions e.g. $1 \div 8 = 1/8$ (g4,5)	21		1	2
Divisibility rules for				
• 2 (g6)	26		2	
• 5 (g6)	25		2	
• 10 (g6)	29		3	
• 100 (g6)	17		2	
• 1 000 (g6)	13		2	
The commutative properties with whole numbers [for addition of two numbers: $a + b = b + a$, for all numbers a and b - e.g. $5 + 4 = 4 + 5$; for multiplication of two numbers: $a \times b = b \times a$, for all numbers a and b (e.g. $5 \times 4 = 4 \times 5$)] (without learners necessarily teaching the term 'commutative') (g5,6)	29		2	2
The associative properties with whole numbers [for addition of three or more numbers: $(a + b) + c = a + (b + c)$, for all numbers a , b and c - e.g. $(12 + 2) + 8 = 12 + (2 + 8)$; for multiplication of three or more numbers: $(a \times b) \times c = a \times (b \times c)$, for all numbers a , b and c - e.g. $(12 \times 2) \times 8 = 12 \times (2 \times 8)$] (without necessarily teaching the term 'associative') (g5,6)	25		2	2
The distributive properties with whole numbers [for multiplication over addition: $a \times (b + c) = (a \times b) + (a \times c)$, for all numbers a , b and c - e.g. $5 \times (3 + 4) = (5 \times 3) + (5 \times 4)$] (without necessarily teaching the term 'distributive') (g5,6)	17		2	2-4

SECTION 2 : MEASUREMENT:

		% of classes that covered	Estimated average number of lessons spent on content		Ideal – number single 30 min periods
			Less than one	If one or more, estimated average no. single periods	
2.1 TIME					
Reading and writing analogue, digital and 24-hour time including:					
Analogue time (time read from a clock with a face and hands)					
• to the nearest minute (g4.5.6)	50		2	2	
• to the nearest second (g4.5.6)	42		2	2	
Digital time (time read from a clock that has a continually changing digital display rather than a clock face)					
• to the nearest minute (g4.5.6)	33		1	1	
• to the nearest second (g4.5.6)	21		1	1	
24-hour time					
• to the nearest minute (g4.5.6)	29		1	1-2	
• to the nearest second (g4.5.6)	28		1	1-2	
Solving problems involving calculation and conversions between appropriate time units including:					
• seconds (g4)	58		1		
• minutes (g4)	67		1		
• hours (g4)	63		1		
• days (g4)	63		1		
• weeks (g4)	50		1		
• months (g4)	50		1		
• years (g4)	42		1		
• decades (g5)	40	X		1	
• centuries (g5)	0		0	1	
• millennia (g5)	0		0	1	
• time zones and differences (g6)	0		0		
Using time-measuring instruments with precision(accuracy) including:					
• clocks (g4)	21		1		
• watches (g4.5)	13		1	1	
• stopwatches(g5)	0		0	1	
2.2 UNITS AND INSTRUMENTS					
2.2.1 MASS, CAPACITY AND LENGTH					
Estimating, measuring, comparing, calculating and converting S.I. units with appropriate precision including:					
• Mass using kilo-grams(kg) (g4.5.6)	58		2	2	
• Mass using grams (g) (g4.5.6)	58		2	2	
• Capacity using litres (l) (g4.5.6)	42		2	2	
• Capacity using millilitres (ml) (g4.5.6)	42		2	2	
• Length using metres (m) (g4.5.6)	46		1	2	
• Length using centimetres (cm) (g4.5.6)	50		2	2	
• Length using millimetres (mm) (g4.5.6)	50		2	2	
• Length using kilometres (km) (g4.5.6)	33		2	2	
• Temperature using degree Celsius scale (g5.6)	0		0	1	
Using measuring instruments for measuring:					
Mass					
• Using bathroom scales (g4.5.6)	17		1	2	
• Using kitchen scales (g4.5.6)	21		1	2	
• Using balances (g4.5.6)	0		0	2	
Capacity					
• Using measuring jugs (g4.5.6)	8		1	2	
Length					
• Using rulers (g4.5.6)	38		1	2	
• Using meter sticks (g4.5.6)	17		1	2	
• Using tape measures (g4.5.6)	21		1	2	
• Using trundle wheels (g4.5.6)	0		0	2	

		% of classes that covered	Estimated average number of lessons spent on content		Ideal – number single 30 min periods
			Less than one	If one or more, estimated average no. single periods	
	Temperature:				
	• Using thermometers (g5.6)	0	X	0	2
	2.2.2 PERIMETER, AREA, VOLUME				
	Measuring and approximating including:				
	Perimeter:				
	• Using rulers (g4.5 & 6)	21		2	2
	• Using measuring tapes (g4.5,6)	0		0	2
	Area of:				
	• polygons (using square grids and tiling) to develop understanding of square units (g4.5)	4		1	4
133	• polygons (using square grids and tiling) to develop rules for calculating the area of squares and rectangles (g6)	4		2	
134	• circles (g6)	4		1	
135	• squares (g6)	17		3	
136	• rectangles (g6)	21		4	
	Volume/capacity of				
	• 3-D objects (by packing or filling them) to develop rules an understanding of cubic units (g4.5)	4		2	4
138	• objects (by packing or filling them) to develop rules for calculating volume of rectangular prisms (g6)	0		0	
	Investigation relationships between				
139	• the perimeter and area of rectangles (g6)	4		5	
140	• the perimeter and area of squares (g6)	4		2	
141	• surface area, volume and the dimensions of rectangular prisms (g6)	0		0	
	Recognising and describing angles in 2-D shapes, 3-D objects and the environment including:				
	• Right angles (g5.6)	25		1	2
	• Angles smaller than right angles (g5.6)	25		2	1
	• Angles greater than right angles (g5.6)	25		2	1

SECTION 3: SPACE AND SHAPE (GEOMETRY):

3.1 SHAPES AND OBJECTS	% of classes that covered	Estimated average number of lessons spent on content		Ideal number single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
Recognising and naming 2-D shapes and 3-D objects in natural and cultural forms and geometric settings such as:				
• Rectangular prisms (g4)	25		1	
• Spheres (g4)	25		1	
• Cylinders (g4)	21		1	
• Prisms and pyramids (g4)	21		1	
• Circles (g4)	33		1	
• Rectangles (g4)	42		1	
• Polygons in terms of the number of sides up to 8 sided figures (g4)	42		1	
• Other objects (g4)	8		1	
Recognising and naming similarities and differences between:				
• squares and rectangles (g5)	25		1	2
• cubes and rectangular prisms (g5)	13	X		2
• tetrahedrons (a polyhedron with four faces) and other pyramids (g6)	8	X		
• rectangles and parallelograms (g6)	25		1	
Describing, sorting and comparing geometrical properties of 2-D shapes and 3-D objects according to:				
• Shapes of faces (g4,5,6)	17		1	1
• Number of sides (g4,5,6)	21		1	1
• Number of faces (g5,6)	17		1	1
• Flat and curved surfaces/straight and curved sides (g4)	8		1	
• Edges (where two faces of a solid object meet) (g6)	8		1	
• Vertices (the point where the arms of an angle meet, the point where edges of a polyhedron meet, the apex of a cone) (g6)	13		1	
• Lengths of sides (g5 & 6)	13		1	2
• Angle size of corners (g6)	8		2	
Making 2-D and 3-D models				
• of geometric objects using cut out polygons (g4,5)	8		4	4
• of geometric objects (example boxes) to trace nets (g5)	4		1	4
• by drawing shapes on grid paper (g4,5,6)	4		2	4
• using drinking straws to make a skeleton (g6)	0		0	
• using nets (a flat diagram from which a model of a polyhedron can be made) (g6)	4		2	
• using a pair of compasses to draw circles, patterns in circles and patterns with circles (g6)	0		0	

		Estimated average number of lessons spent on content		
	% of classes that covered	Less than one	If one or more estimated average no. single periods	Ideal number single 30 min periods
3.2. TRANSFORMATIONS				
Recognising and describing lines of symmetry in 2-D shapes including those in natural and cultural art forms (g4)	0		0	
Using geometric figures and solids to recognise, describe and perform:				
• Rotations (turns – a transformation under which an object is turned around a fixed point called the centre of rotation into a new position) (g5)	0		0	2
• Reflections (flips – a transformation which produces a mirror image of the same shape and size as the original, but reversed) (g5)	4		1	2
• Translations (slides – a transformation under which a shape or object is moved by sliding into a new position) (g5)	0		0	2
Using the vocabulary and properties of rotations, reflections and the translations to describe the relationships between distinct 2-D shapes and 3-D objects and within patterns (including translations and symmetry) (g6)	0		0	
Making and describing 2-D shapes, 3-D objects and patterns from geometric objects and shapes (e.g. tangrams) in terms of:				
• Tessellations (tiling – formed by fitting shapes together to cover a plane without overlapping or leaving gaps) (g4.5)	8		1	4
• Line symmetry (g4.5)	8		1	4
• Rotational symmetry (g5)	8			4
• Movement including rotations, reflections and translations (g5)	0		0	4
• Geometric properties (g4.5.6)	4		1	2-4
Drawing enlargements and reductions of 2-D shapes (at least quadrilaterals and triangles) using grid paper to compare their size and shape (g6)	4		1	
3.3 POSITION				
Describing changes in the view of an object held in different positions (g4)	4		1	
Describing views of a simple 3-D object from different positions (perspectives) (g5)	0		0	4
Making sketches of a simple 3-D object from different positions (perspectives) (g6)	4		1	
Locating position on a coded (labelled) grid including maps:				
• from given instructions by column and row (g4)	4		1	
• by tracing paths between positions following verbal and written instructions (g5.6)	4		1	4
Recognising maps as grids (g6)	0		0	

SECTION 4: PATTERNS, FUNCTIONS AND ALGEBRA

	% of classes that covered	Estimated average number of lessons spent on content		Ideal – number single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
4.1 PATTERNS				
Investigating and extending numeric and geometric patterns:				
• Represented in physical or diagrammatic form (g4.5.6)	38		3	2
• Not limited to sequences involving constant difference or ratio (g4.5.6)	21		1	2
• Found in natural and cultural contexts (g4.5.6)	13		2	4
• Of the learner's own creation (g4.5.6)	13		1	2
• Represented in tables (g6)	13		3	
Describing observed relationships or rules of numeric and geometric patterns (g4.5.6)	4		1	8
4.2 EQUATIONS				
Determining output values for given input values using:				
• Verbal descriptions (g4.5.6)		1	2	
• Flow diagrams (a diagram which shows the steps to be followed in solving a problem) (g4.5.6)		2	2	
• Tables (g6)		2		
Writing number sentences describing a problem situation including problems within contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues (g4.5.6)		1	2-4	
Solving or completing open number sentences by inspection or by trial-and-improvement, checking the solutions by substitution, e.g. $\square \div 4 = 12$ or $2 \times \square - 8 = 0$ (5.6)		3	2-4	
4.3 EQUIVALENT REPRESENTATIONS				
Determining the equivalence of different descriptions of the same relationship or rule presented:				
• Verbally (g4.5.6)	6		1	2
• In flow diagrams (g4.5.6)	4	X		2
• By number sentences (g4.5.6)	4	X		2
• In tables (g6)	4	X		

SECTION 5: DATA HANDLING:

5.1 COLLECTING AND ORGANISING DATA	% of classes that covered	Estimated average number of lessons spent on content		Ideal number single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
Posing simple questions and data sources that address human rights, social, political, cultural, environmental and economic issues in learners' school and family environment (g4, 5.6)	38		4	2
Making and using simple data collection sheets involving counting objects (requiring tallies i.e. ways of recording the number of items per category in a set of data by making a mark for each item) and simple questionnaires (with yes/no type responses) to collect data to answer questions posed by the teacher or learners (g5.6)	38		3	4
Using tallies and tables to organise and record data (g5.6)	21		3	2
Using ungrouped numerical data (raw data which have not been grouped into classes or categories) to determine:				
<ul style="list-style-type: none"> the most frequently occurring score (mode i.e. the number or item that appears most frequently in a set of data) in order to describe central tendencies (g4, 5.6) 	25		2	2
<ul style="list-style-type: none"> the midpoint (median i.e. if the data is written in order from smallest to largest, the median is either the middle number or the mean of the two middle numbers) in order to describe central tendencies (g5.6) 	4		1	2
5.2 REPRESENTING AND INTERPRETING DATA				
Drawing graphs to display and interpret ungrouped data including:				
<ul style="list-style-type: none"> Pictographs (a graph which makes use of pictures e.g. people, cars, etc. to represent data) with one to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g4) 	33		3	
<ul style="list-style-type: none"> Pictographs with a many to one correspondence and appropriate keys (e.g. one picture = 10 persons) (g5.6) 	17		3	2
<ul style="list-style-type: none"> Bar graphs (uses vertical or horizontal bars to represent information) (g4, 5.6) 	3		3	2-4
<ul style="list-style-type: none"> Double bar graphs (g6) 	0		0	2
Reading and interpreting data presented in a variety of ways (including own representations and representations in the media – both words and graphs) to draw conclusions and make predictions sensitive to the role of:				
<ul style="list-style-type: none"> Context (e.g. rural or urban, national or provincial) (g4, 5.6) 	4		6	2
<ul style="list-style-type: none"> Categories within the data (e.g. age, gender and race) (g5.6) 	4		1	1
<ul style="list-style-type: none"> Other human rights issues (g4, 5.6) 	0		0	1
Comparing, classifying and ordering events from daily life on a scale from certain that they will happen to certain that they will not happen (g4.5)	4		1	2
Predicting the likelihood of events in daily life based on observation and placing them on a scale from impossible to certain (g6)	4		1	

	% of classes that covered	Estimated average number of lessons spent on content		Ideal number single 30 min periods
		Less than one	If one or more, estimated average no. single periods	
Listing possible outcomes for simple experiments including:				
• tossing a coin (g5,6)	4	X		1
• rolling a die (g5,6)	4	X		1
• spinning a spinner (g5,6)	0		0	1
Counting:				
• the number of possible outcomes for simple trials (g4)	0		0	
• the frequency of actual outcomes for a series of trials (g5,6)	0		0	2

APPENDIX 16:

The curriculum generally made
available to grade 5 learners

The curriculum generally made available to grade 5 learners by the end of the third term 2003 (i.e. at least 50% of classes covered this content)

Shading indicates that the content reflects grade 6 level expectations.

LO 1: NUMBER, OPERATION AND RELATIONSHIPS

Recognising, classifying and representing numbers

Counting backwards and forwards in 2s, 3s, 5s, 10s, 25s, 50s, 100s (on average 1 lesson on

Representing and comparing whole numbers to 4 (on average 3 lessons – grade 4 level)

Representing and comparing odd and even numbers (on average 2 lessons – grade 4 level)

Representing and comparing common fractions in diagrammatic form (on average 2 lessons – grade 4 level)

Representing and comparing common fractions with different denominators including halves, thirds, quarters, fifths, sixths, sevenths, eighths (grade 4 level), tenths, hundredths (grade 5 level) (on average 1 lesson on each)

Representing and comparing factors of any 2-digit whole numbers (on average less than 2

Representing and comparing multiples of single digit numbers to 100 (on average 4 lessons – grade 4, 5 level)

Place values of digits in whole numbers up to 4-digit numbers (on average 6 lessons – grade 4 level)

Equivalent forms of rational numbers including common fractions with denominators that are multiples of each other (on average 3 lessons – grade 4, 5 level)

Equivalent forms of rational numbers including common fractions with 1-digit and 2-digit denominators (on average 2 lessons – grade 5 level)

Applications of numbers to problems

Solving problems in different contexts such as financial (e.g. buying and selling) (on average 3 lessons – grade 4, 5 level)

Using operations appropriate to solving problems involving rounding off the nearest 10 (on average 2 lessons), 100 (on average 2 lessons – grade 4, 5 level)

Using operations appropriate to solving problems involving addition and subtraction of whole numbers with 4 (on average 5 lessons – grade 4 level) and 5 digit numbers (on average 4 lessons – grade 5, 6 level)

Using operations appropriate to solving problems involving addition and subtraction of common fractions in context (on average 1 lessons – grade 4 level)

Using operations appropriate to solving problems involving multiplication of whole 2-digit by 2-digit numbers (on average 3 lessons – grade 4 level) and whole 3-digit by 2-digit numbers (on average 4 lessons – grade 5 level)

Using operations appropriate to solving problems involving division of 3-digit by 1-digit whole numbers (on average 3 lessons – grade 4 level)

Calculation types involving numbers

Mental calculations involving addition and subtraction (on average 3 lessons on each (6) – grade 4, 5, 6 level)

Mental calculations involving multiplication of whole numbers up to 10×10 (on average 3 lessons – grade 4, 5 level) and 12×12 (on average 2 lesson – grade 6 level)

Written and mental calculations with whole numbers involving addition and subtraction in columns (on average 7 lessons – grade 5, 6 level)

Written and mental calculations with whole numbers involving multiplying in columns (on average 5 lessons – grade 6 level)

Written and mental calculations with whole numbers involving building up and breaking down numbers (on average 5 lessons – grade 4, 5, 6 level)

Written and mental calculations with whole numbers involving doubling and halving (on average 2 lessons – grade 4, 5 level)

LO 4: MEASUREMENT

Time

Analogue time to the nearest minute (on average 2 lessons – grade 4, 5, 6 level)

Solving problems involving calculations and conversions between appropriate time units including minutes and seconds, hours, days, weeks and months (on average 1 lesson on each (6) – all grade 4 level)

Units and instruments

Mass, capacity and length

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units with appropriate precision for mass using kilograms and grams (on average 2 lesson – grade 4, 5, 6 level)

Estimating, measuring and comparing 2-D shapes and 3-D objects using SI units with appropriate precision for length using centimetres and millilitres (on average 2 lessons – grade 4, 5, 6 level)

APPENDIX 17:

Graphs for model checking for Opportunity-to-Learn

Graphs for Model Checking: Opportunity-to-learn

Figure 9: Residuals vs absent (model 1)

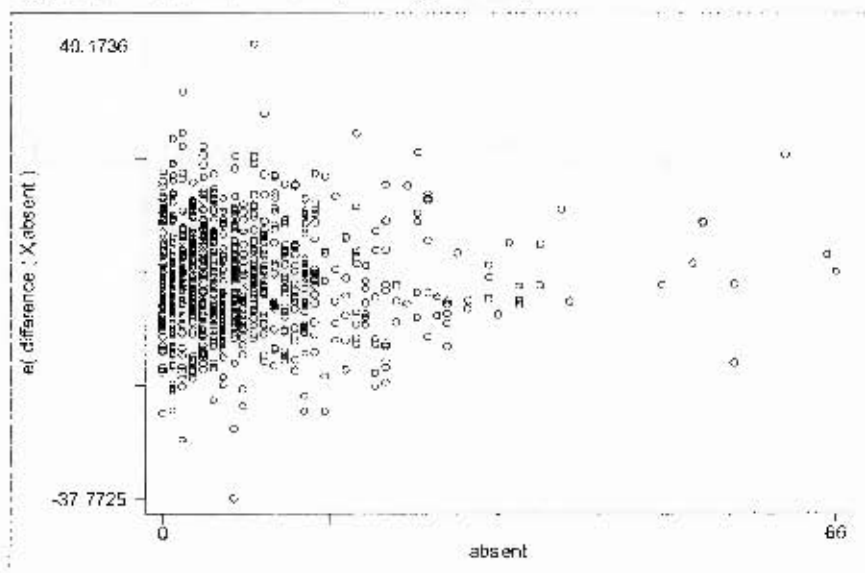


Figure 10: Residuals vs logabsent (model 1)

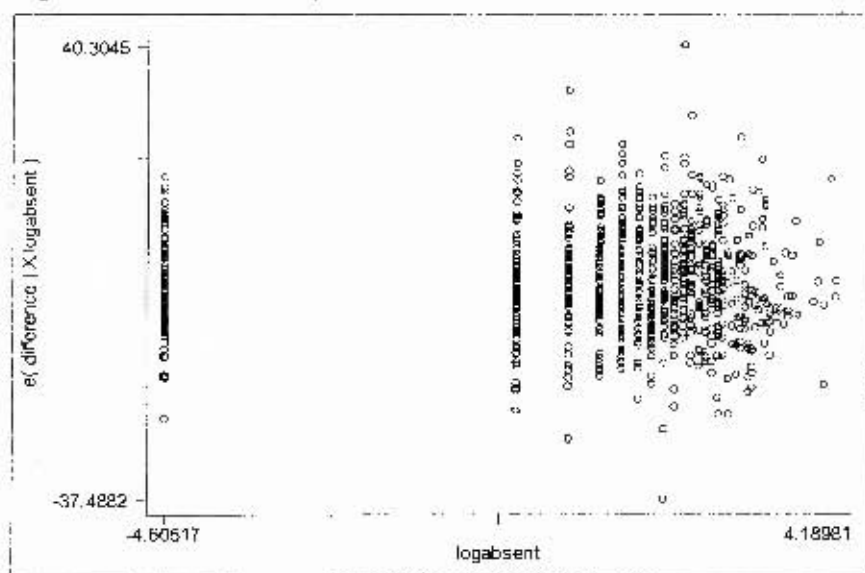


Figure 11: Histogram of residuals (model 1)

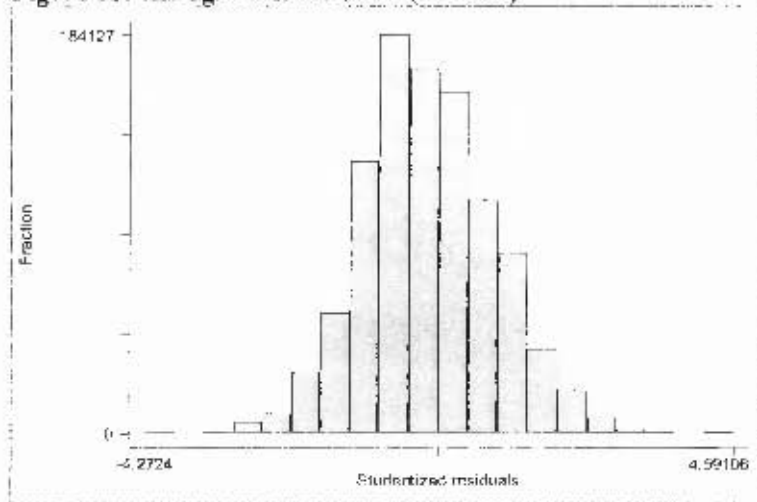


Figure 12: Normal probability plot (model 1)

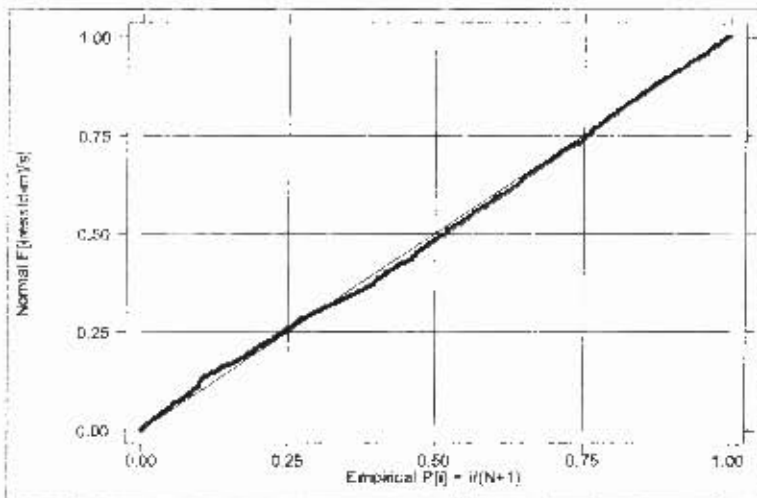


Figure 13: Checking constant variance (model 1)

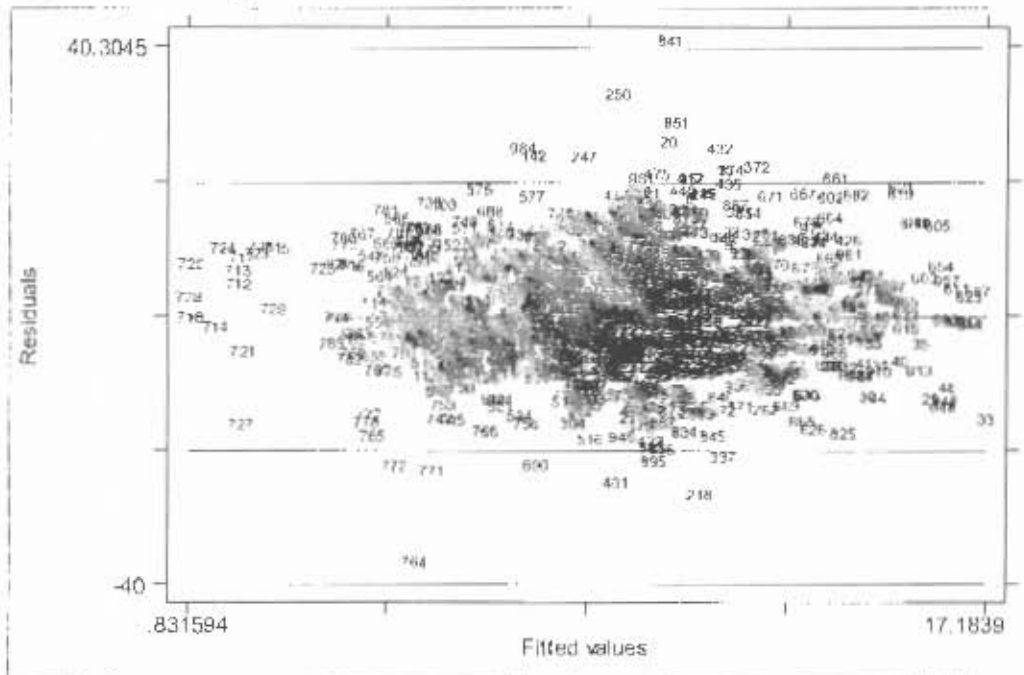


Figure 14: Residuals vs cognitive demand (model 1)

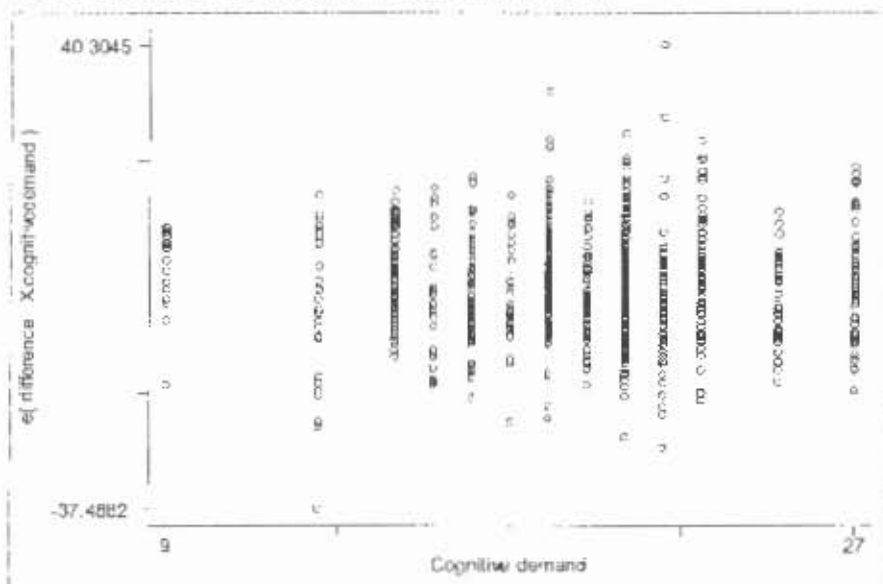
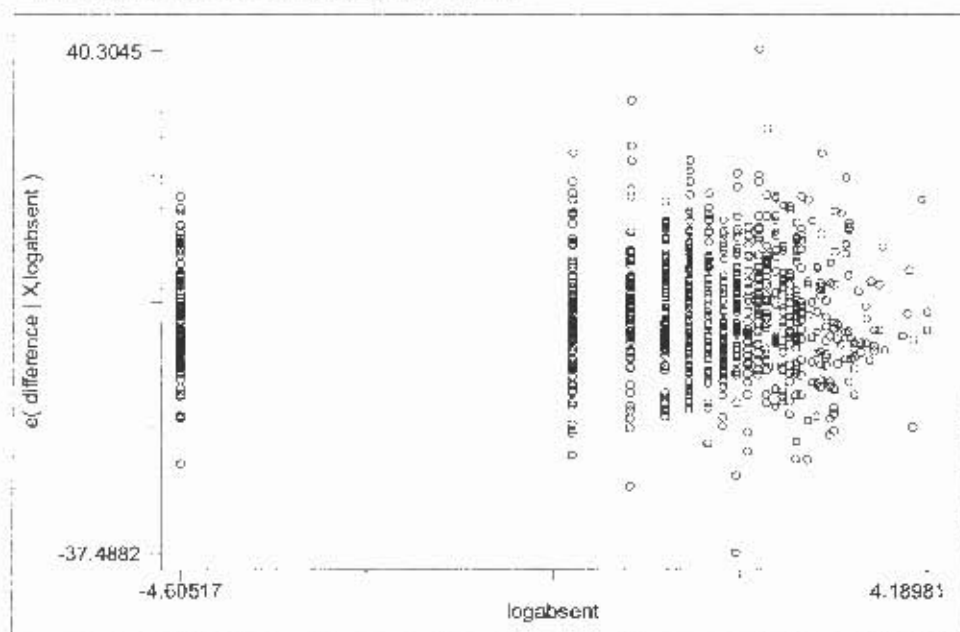


Figure 15: Residuals vs logabsent (model 1)



APPENDIX 18:

Illustrative examples from field notes
for ‘type of pedagogy’

Illustrative examples from field notes for 'type of pedagogy'

'Barely discernible' teacher-learner hierarchical relations

Many of the learners were extremely rowdy and almost uncontrollable throughout the lesson. The power relations were such that some learners openly defied or teased the teacher. For example, when the teacher first asked them what they had done in the previous lesson and where their books were, she had to repeat herself more than once. Whilst this was going on, two learners were fighting over a seat. The teacher did not react but simply gave out two new notebooks to two learners who claimed that they had lost theirs. Later, when a girl was told to go and spit her chewing gum in the dustbin, quite a few learners chirped 'Spoeg dit uit.' (Spit it out). Others said, 'Laat sy dit insluk juffrou!' (Make her swallow it miss). At one point a learner began to whistle a tune. Although the teacher said, "Sabasto, ek weet nie hoekom jy vandag so stout is nie" (Sabasto, I don't know why you are so naughty today), she did not do anything else. At 09h30, the teacher told the class to open their books but very few of them did as instructed. She said, "Jou laaste werk" (Your previous work) as she started walking about, trying to see who had done the homework. She told learners to stay in their places but various learners got up from their desks and wandered around. It seemed that learners rather than the teacher determined the nature of the classroom context and their relationship with the teacher. The teacher seemed unable to get the class to take her seriously.

'Barely discernible' learner-learner hierarchical relations

Learners' responses were mostly in the form of a 'chorus', where everybody called out simultaneously. The teacher tended to pose questions to the whole class and address them as a collective making for a rather homogeneous treatment of all. Although she occasionally addressed and called on individuals, her whole class interaction was not used to identify learners who were giving correct responses from those who were not. Learners were subsequently meant to complete tasks alone but there was discussion between partners about the answers. Performances were not used to differentiate between those who were coping mathematically and those who were not.

'Barely discernible' framing over the discursive rules. (Note: this was a lesson given to the only class where learners were afforded a choice over selection and sequencing – however, their choices appeared to be unconstrained.)

Selection

Maths knowledge was linked to other subjects through the use of a cross curricular theme 'the environment' and was embedded in the everyday world. The focus of the lesson was on discovering that 'mathematics is everywhere in the real world.' Learners had to use 'waste products' such as cereal boxes, bottles, packets etc. that they had brought from home. The task given to the learners was to find 'something of interest' on the items. The 'unexpressed' expectation appeared to be that they would select texts that they would classify as 'maths', more specifically, 'numbers', such as bar-codes, units of measurement, sell by dates, etc. However, the teacher gave them no criteria for selecting items, only hinting at one point what was required (that is, text that related to maths) by saying 'Remember I am your maths teacher'. After learners had found 'something of interest on the objects', they had to 'write a journal of what happened' and answer the following questions:

- a) What did I do? [For example, cutting, selecting, pasting 'facts' from the object]*
- b) What did I learn? [For example, one learner responded that he had learnt the word 'journal.' Some learners answered, 'numbers', 'prices', 'bar-codes' and various units of measurement]*

Sequencing

Learners could work in any order they chose. Progression or increasing levels of difficulty were not evident.

Pacing

Learners seemed to have unconstrained control over the pace which was very slow. Apparently they could take as long as they wanted and no time limits were set.

APPENDIX 19:

Analytical framework for ‘type of pedagogy’

ANALYTICAL FRAMEWORK: TYPE OF PEDAGOGY			
CLASSIFICATION – POWER	WEAK CLASSIFICATION		STRONG CLASSIFICATION (2)
Instructional context			
RELATIONS BETWEEN DISCOURSES: INTER-DISCURSIVE RELATIONSHIPS			
Whether the boundary between mathematics and everyday discourse is blurred			
1. SCHOOL MATHEMATICS AND EVERYDAY DISCOURSE		Mathematics knowledge and everyday knowledge are related. Everyday discourse or contexts are brought into the classroom. For example, through embedding maths knowledge in real world problems, the recruitment of everyday knowledge to support conceptual development of maths knowledge or through the application of Maths knowledge in real world applications, etc.	Mathematics knowledge and everyday knowledge are unrelated. Everyday discourse or contexts are not brought into the classroom. No or only very superficial references are made to related everyday knowledge.
2. MATHEMATICS AND OTHER SCHOOL SUBJECTS		Interdisciplinary relations are promoted through the use of themes. Mathematics knowledge is integrated with other school subjects through themes.	Mathematics discourse is separated from the discourse of other school subjects. Interdisciplinary relations are not promoted. Mathematics knowledge is not integrated with other school subjects through themes.
FRAMING – CONTROL			
Whether the teacher controls the selection, sequencing and pacing of content			
7. THE SELECTION RULE	Framing over selection is almost indistinguishable. Learners appear to have unconstrained control over selection - the selection of contents, activities or materials are very loosely bounded for most learners and in relation to grade 6 curriculum requirements.	Learners appear to have a degree of influence over decisions around the selection of activities, materials, or contents with the teacher adjusting selection according to the average learners' level of capability.	The teacher determines the selection of activities, materials, or contents and uses pre-selected contents, materials or contents without adjusting selection according to the average learners' level of capability even when the work is too difficult for most learners.
8. THE SEQUENCING RULE	Framing over sequencing is almost indistinguishable. Learners appear to have unconstrained control over sequencing - the sequence is very loosely bounded for most learners and in relation to curriculum requirement.	Learners appear to have a degree of influence over decisions around the order of activities, materials and contents with the teacher adjusting sequencing according to the average learners' level of progress. For example, by revisiting or reviewing work only when necessary for most learners.	The teacher determines the order or sequencing of activities, materials or contents and follows a pre-set order without adjusting sequencing according to the average learners' level of progress even when most learners are unable to progress.
9. THE PACING RULE	Framing over pacing is almost indistinguishable. Learners appear to have unconstrained control over pacing - the pace is very loosely bounded for most learners and in relation to curriculum expectations.	Learners have a degree of influence over decisions around pacing of the contents, activities or materials with the teacher adjusting pacing according to the average learner's rate of progress.	The teacher determines the pacing of contents, activities or materials and keeps to time limits without adjusting pacing according to the average learners' rate of progress even when most learners cannot keep up.

FRAMING – CONTROL		BARELY DISCERNIBLE FRAMING F (0)		WEAK FRAMING F (1)		STRONG FRAMING F+ (2)	
Instructional context cont.							
Discussion and evaluation							
Evaluation criteria							
Whether the criteria for evaluation are implicit or explicit							
10. CRITERIA FOR EVALUATION		The criteria for evaluation are almost indistinguishable. Access to the evaluation criteria is through explorations of contexts or problems but the teacher does not use learners' efforts or responses (exploration and discussion) to draw out and elaborate on the evaluation criteria.		The criteria for evaluation are implicit <i>a priori</i> . Access to the evaluation criteria is through explanations of contexts or problems and the teacher uses learners' efforts or responses (exploration and discussion) to draw out and elaborate on the evaluation criteria.		The criteria for evaluation are explicit <i>a priori</i> . Access to the evaluation criteria is directly through expositions of worked solutions and detailed demonstrations of procedures to follow <i>a priori</i> .	
Whether the criteria for evaluating texts for evaluation are implicit or explicit							
11. CRITERIA FOR LEGITIMATE REALISATIONS OF TEXTS FOR EVALUATION		The criteria for legitimate realisation of texts for evaluation are almost indistinguishable. Learners' responses or products are treated as equally valid and the teacher provides no hints or cues as to which responses or products are correct or more successful. Evaluation of focuses neither on what is 'present' nor on what is 'missing'.		The criteria for legitimate realisation of texts for evaluation are implicit. The teacher provides hints or indicates which responses or products are correct or more successful. Evaluation of learners' texts focuses on what is 'present' rather than on what is incorrect and 'missing.' Learners' products or responses are undifferentiated in terms of how (in what ways) they are unsuccessful/ incorrect.		The criteria for legitimate realisation of texts for evaluation are explicit. The teacher judges responses or products as correct and incorrect, and uses error to identify and provide feedback on what is missing from incorrect answers. Evaluation of their texts focuses on what is incorrect and 'missing.' Learners' products or responses are clearly differentiated in terms of how (in what ways) they are unsuccessful/ incorrect.	

Regulative context			
CLASSIFICATION - POWER	HAZARDY/ DISCERNIBLE CLASSIFICATION (0)	WEAK CLASSIFICATION C- (1)	STRONG CLASSIFICATION C+ (2)
RELATIONS BETWEEN SPACES Whether the boundaries between the teacher's and the learners' space is distinct or blurred.			
5. TEACHER-LEARNER SPACES		Classification of space in the classroom facilitates weakly framed social relationships between the teacher and learners and de-emphasises the teacher's position of power. The teacher and learners mostly share spaces. Learners continually move into the teacher's space to 'display' their answers and/or the teacher spends more time in the 'learners' space.	Classification of space in the classroom promotes strongly framed social relationships between the teacher and learners and emphasises the teacher's position of power. The teacher and learner mostly remain in their own spaces. Learners never or hardly ever entered the teacher's space to 'display' their answers on the board and/or the teacher spends more in his/her space.
Whether the boundaries between the teacher's and the learners' space is distinct or blurred.			
6. LEARNER-LEARNER SPACES		Classification of space in the classroom facilitates weakly framed social relationships between learners. Learners share spaces with one another. For example, they are seated at desks or tables clustered together.	Classification of space in the classroom promotes strongly framed social relationships between learners. Learners' spaces are separated from each other. For example, learners are seated individually at desks in rows or in pairs at two-seater desks and each have their own material.
RELATIONS BETWEEN SUBJECTS/AGENTS Whether the hierarchical relations between the teacher and learners are masked or clear.			
3. TEACHER-LEARNER RELATIONS	The teacher's social status, authority or power is indiscernible. The teacher seems powerless to determine the characteristics of the instructional and regulative context. Learners rather than the teacher appear to determine the characteristics of the classroom contexts.	The teacher's social status, authority or power is covert. The fact that the teacher defines the characteristics of the instructional and regulative contexts is 'masked'. Learners appear to be self-regulating and to take personal responsibility for initiating actions and following routines themselves.	The teacher's social status, authority or power is overt. The fact that the teacher defines the characteristics of the instructional and regulative contexts is clear. The teacher openly regulates learners' actions and asserts her/his position of authority or power, for example, by frequently making sure that learners focus attention on him/her and wait for his/ her instructions or directions before acting.
Whether the hierarchical relations between learners are masked or clear.			
4. LEARNER-LEARNER RELATIONS	Hierarchical relations between learners are indiscernible. Hierarchies between learners are neither clear nor 'masked'. Stems are collectivised or homogenised to the extent that their pedagogical identities as maths learners are neither performance nor competence-based.	Possible hierarchies between learners are 'masked'. Learners' pedagogical identities as maths learners are based on shared competence established through equal participation in joint productions and/or equal inter-personal intervention from the teacher.	Hierarchies between learners are clear. Learners' pedagogical identities as maths learners are based on private performances used to differentiate learners in terms of those who are able to respond successfully and those who are not.

FRAMING – CONTROL		BARELY DISCERNIBLE FRAMING		WEAK FRAMING	
		5. (0)		6. (1)	
Hierarchical rules		Whether communication relations are opened by the teacher and learners		Whether communication relations are opened by the teacher and learners	
12. COMMUNICATION RELATIONS BETWEEN THE TEACHER AND THE LEARNERS	Framing over teacher-learner communication relations is almost indiscernible. For example, learners call out and make unsolicited comments to the teacher about matters unrelated to mathematics to disrupt teaching and learning	Open teacher-learner communication relations are promoted. Learners initiate interaction with the teacher on their own accord by commenting, interrupting, asking questions about mathematics or requesting assistance from the teacher.	The teacher explicitly closes teacher-learner communication relations. Learners participate in teacher-learner interactions only when invited to do so through the teachers' questioning.		
13. COMMUNICATION RELATIONS BETWEEN LEARNERS	Framing over learner-learner communication relations is almost indiscernible. For example, learners chat about matters unrelated to mathematics in their groups or copy each other's work when they are supposed to work alone.	Learner-learner communication relations are opened. Learners have opportunities to interact and collaborate with one another.	Learner-learner communication relations are closed. Learners have no opportunities to interact and collaborate with their peers.		

APPENDIX 20:

Boxplots for 'type of pedagogy'
and chi-squared tables

Boxplots: 'type of pedagogy'

Figure 17: Achievement gain by framing over evaluation criteria (Evalcrit_pre)

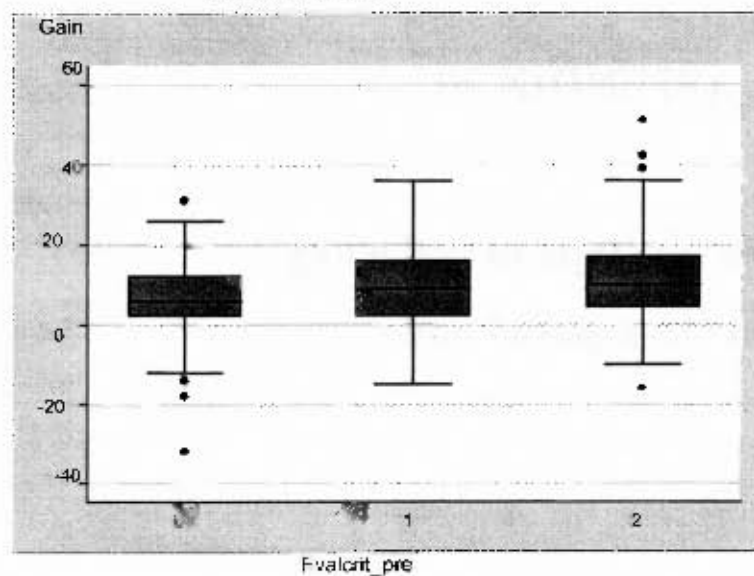


Figure 18: Achievement gain by framing over the criteria for evaluating texts for evaluation (Evalcrit_post)

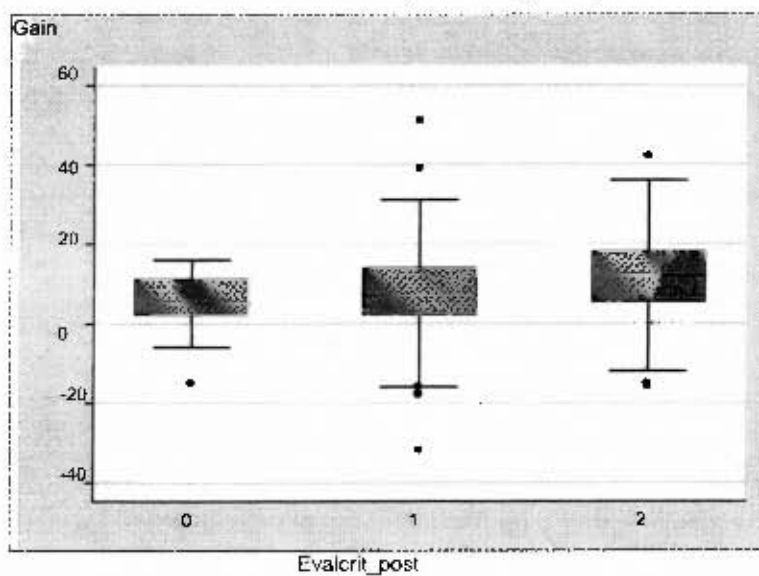


Figure 19: Achievement gain by framing over micro selection

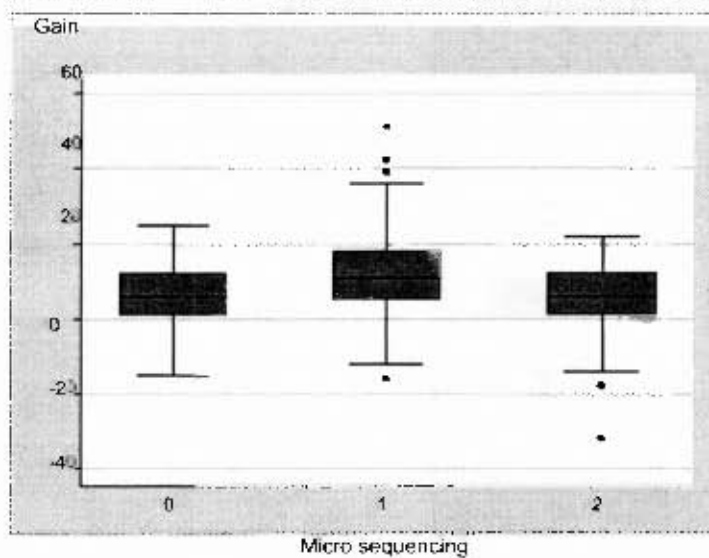


Figure 20: Achievement gain by framing over micro sequencing

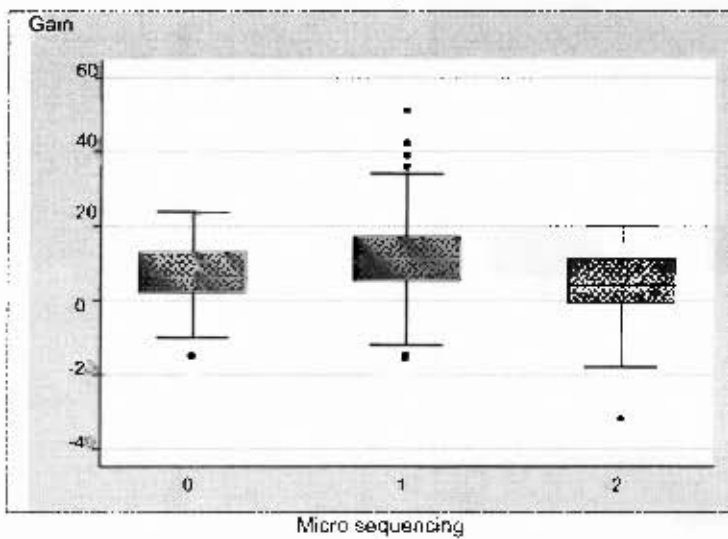


Figure 21: Achievement gain by framing over micro pacing

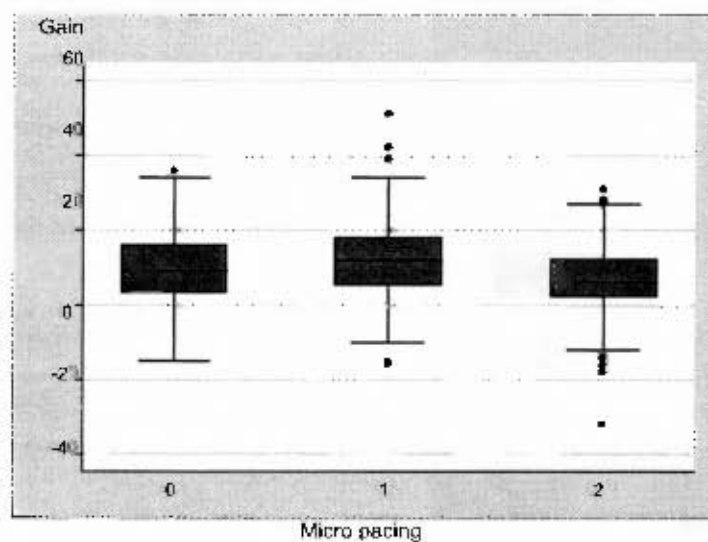
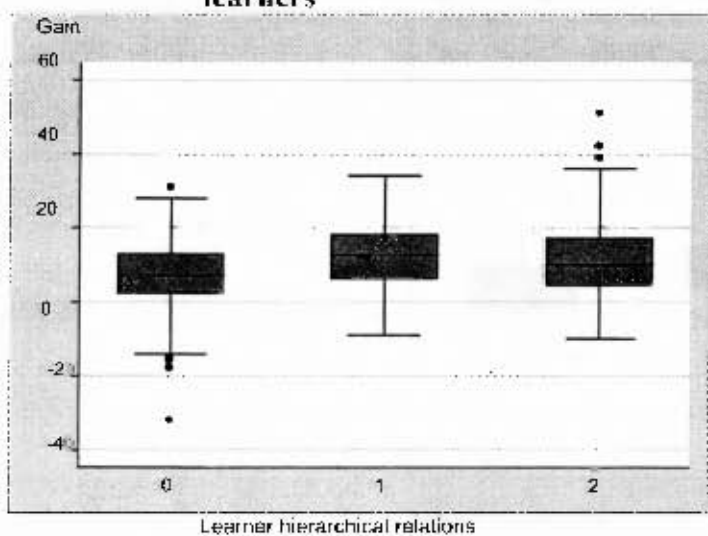


Figure 22: Achievement gain by framing over hierarchical relations between learners



Chi-squared tables: 'type of pedagogy'

Table 27.1: Micro selection and micro sequencing

selection	sequencing			Total
	F0	F1	F2	
F0	123	83	0	206
F1	26	658	0	684
F2	0	27	84	111
Total	149	768	84	1,001

Pearson $\chi^2(4) = 1.1e+03$ Pr = 0.000

Table 27.2: Micro pacing and micro selection

pacing	selection			Total
	F0	F1	F2	
F0	177	262	27	466
F1	29	342	0	371
F2	0	80	84	164
Total	206	684	111	1,001

Pearson $\chi^2(4) = 472.8619$ Pr = 0.000

Table 27.3: Micro pacing and micro sequencing

pacing	sequencing			Total
	F0	F1	F2	
F0	149	317	0	466
F1	0	371	0	371
F2	0	80	84	164
Total	149	768	84	1,001

Pearson $\chi^2(4) = 647.2535$ Pr = 0.000

Table: 27.4: Criteria for evaluating texts for evaluation (evalcrit_post) and micro selection

eval crit	Selection			Total
	F0	F1	F2	
F0	18	0	28	46
F1	159	139	56	354
F2	29	545	27	601
Total	206	684	111	1,001

Pearson $\chi^2(4) = 434.7109$ Pr = 0.000

Table: 27.5: Criteria for evaluating texts for evaluation (evalcrit_post) and micro sequencing

eval crit	sequencing			Total
	F0	F1	F2	
F0	18	0	28	46
F1	105	193	56	354
F2	26	575	0	601
Total	149	768	84	1,001

Pearson chi2(4) = 425.9443 Pr = 0.000

Table: 27.6: Teacher-learner hierarchical relations and teacher-learner communication relations

hier teach	t/l comm.			Total
	F0	F1	F2	
C0	25	0	27	52
C1	0	53	45	98
C2	0	77	774	851
Total	25	130	846	1,001

Pearson chi2(4) = 628.5852 Pr = 0.000

Table: 27.7: Teacher-learner hierarchical relations and learner-learner communication relations

hier teach	l/l comm.			Total
	F0	F1	F2	
C0	52	0	0	52
C1	27	71	0	98
C2	83	350	418	851
Total	162	421	418	1,001

Pearson chi2(4) = 372.5376 Pr = 0.000

Table: 27.8: Micro selection and hierarchical relations between learners

selection	hier learners			Total
	C0	C1	C2	
F0	179	27	0	206
F1	133	271	280	684
F2	84	0	27	111
Total	396	298	307	1,001

Pearson chi2(4) = 385.9147 Pr = 0.000

APPENDIX 21:

Graphs for model checking for 'type of pedagogy'

Graphs for Model Checking: 'Type of Pedagogy'

Figure 23: Histogram of residuals (model 2)

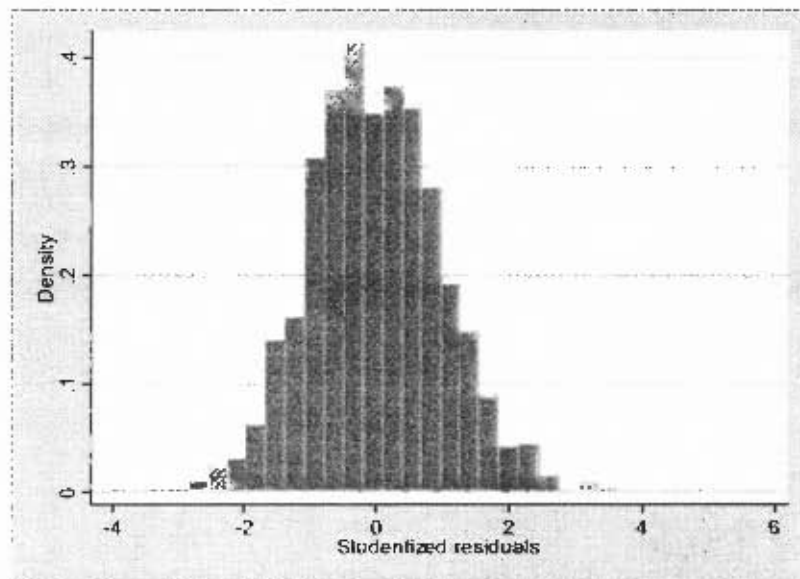


Figure 24: Normal probability plot (model 2)

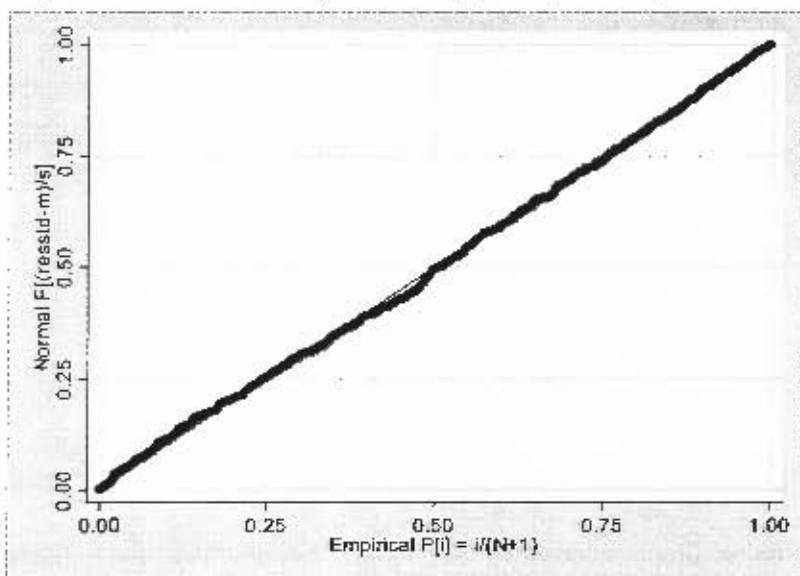
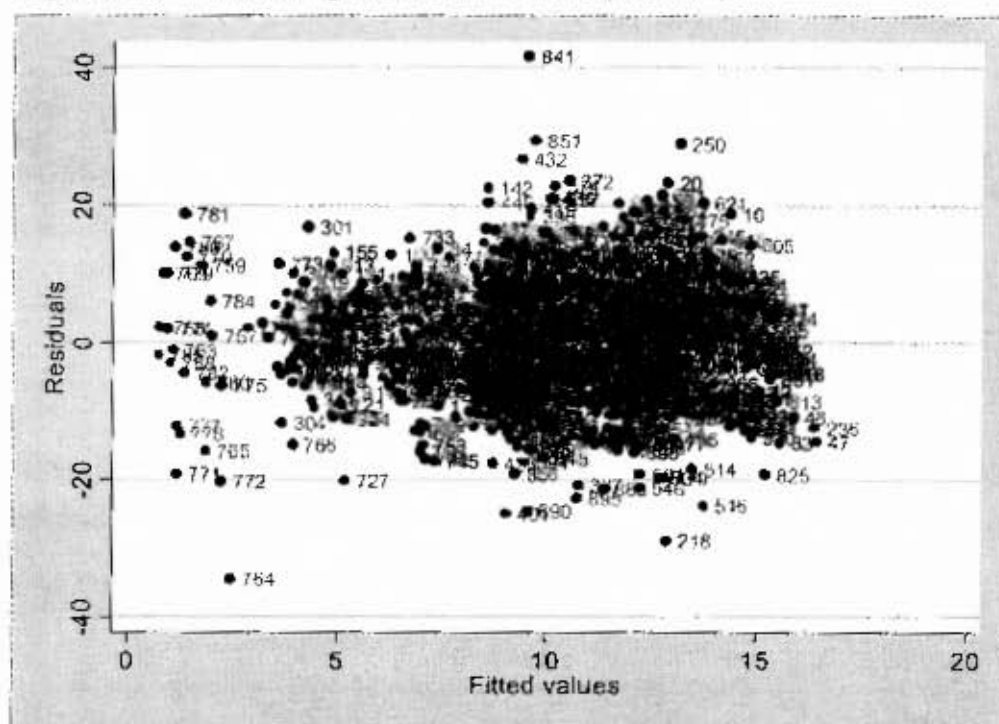


Figure 25: Checking constant variance (model 2)



APPENDIX 22:

Descriptive analysis of learner background variables

Learner Background Variables

Gender

Table 30 below shows that the genders are almost equally represented.

Table 30: Learner gender

Female	52%
Male	48%

Age

The average age of the sample was 12 years with a median and mode of 12. Ages ranged from 10-17. Table 31 provides frequencies for the ages of learners in the sample.

Table 31: Learner ages

Age in years	Number of learners
10	3
11	333
12	415
13	180
14	52
15	12
16	3
17	2
Missing data	1

Family structure

Table 32 provides the percentage of learners who reported that both/one parent/s lived at home. Table 33 provides the percentage of learners who reported that their mother/father did or did not live at home with them.

Table 32: Both/one parent living at home

Both parents	51%
One parent	31%
Neither	11%
Missing	1%

Table 33: Mother/father living at home

Mother lives at home	85%
Mother does not live at home	14%
Missing	1%
Father lives at home	55%
Father does not live at home	44%
Missing	1%

Table 34 reflects the percentage of learners that reported on each of the following as their main caregivers.

Table 34: Main caregivers

Main caregiver	%
Mother	57
Father	6
Grandparent	14
Brother	3
Sister	4
Another relative	5
Another person (not related)	1
Nobody/self	3
Missing	7

Education level of main caregiver

Table 35 shows the percentage of learners who reported that their mothers or main caregivers had finished school.

Table 35: Mother/main caregiver finished school

Yes	45%
No	23%
Don't know	32%
Missing	1%

Table 36 shows the percentage of learners who reported that their mother or main caregiver studied further after leaving school.

Table 36: Mother/main caregiver studied further after school

Yes	18%
No	33%
Don't know	48%
Missing	1%

Language use at home

66% of the sample reported that they mostly or always spoke either English or Afrikaans at home. Table 37 shows learners' reports on English and Afrikaans language use at home.

Table 37: Language use at home

Speak English at home	%
Most or all the time	25
Half the time	30
Another language	45
Missing	1
Speak Afrikaans at home	%
Most or all the time	41
Half the time	34
Another language	22
Missing	3

Settlement type/building

Table 38 shows the percentage of learners who reported living in the two main categories of buildings:

Table 38: Type of home building

Brick/stone buildings	76%
Shacks, huts or wooden buildings	24 %

Table 39 provides the percentage of learners who reported having access to facilities such as electricity and running water at home.

Table 39: Facilities at home

	Yes	No	Missing
Electricity	95%	2%	3%
Running water	85%	12%	3%
Hot water	40%	54%	6%
Flushing toilet	81%	14%	5%

Table 40 provides the percentage of learners who reported on the various categories of safety from crime and violence in the area they lived in.

Table 40: Area safety

'Somewhat safe'	'Very unsafe'	Missing
66%	33%	1%

Basic cognitive resources at home

Table 41 shows the percentage of learners who reported having access to basic cognitive resources such as a quiet room for studying at home.

Table 41: Cognitive resources at home

	Yes	No	Missing
Quiet room for school work	68%	30%	2%
Desk/table for school work	80%	19%	1%
Computer	26%	74%	

Table 42 shows the percentage of learners who reported having the various categories of number of books in their homes.

Table 42: Number of books in home

0-25 books	74%
26-100 books	19%
over 100 books	6%
Missing data	1%

Family expectations/obligations

Table 43 provides percentage of learners who reported on the various categories of family expectations of them after school.

Table 43: Family expectations of learners after school

Study further either at college/university	62%
Finish school and not study further	8%
Did not expect them to finish school	7%
Did not know	18%
Missing	5%

Information channels/parent-child interactions

Table 44 provides percentages of learners who reported on each of the categories for whether an adult person at home talked to them about things they had studied in school or helped them with their homework.

Table 44: Adult help with school/homework

Often	56%
Sometimes	38%
Never	5%
Missing	1%

Table 45 provides percentages of learners who reported on each of the categories for whether their parents or caregivers had attended a meeting at their school this year.

Table 45: Parent attendance at school meeting this year

Yes	69%
No	18%
'Don't know'	12%
Missing	1%

Table 46 provides the percentage of learners who reported on each of the categories for whether their parents or caregivers knew their friends well.

Table 46: Parents' knowledge of friends

Know them well	59%
A little or not all	40%
Missing	1%

Network resources including concurrent learning

Table 47 shows the percentage of learners who reported on each of the categories for whether their mothers or caregivers often got together with other people outside of their family to do or talk about things (for example, to sing in a church choir or to discuss community problems).

Table 47: Mothers' community involvement

Often	33%
Sometimes	36%
Never/Don't know	30%
Missing	1%

Table 48 shows the percentage of learners who reported that they had/had not had extra mathematics lessons with a teacher who is not from their school.

Table 48: Extra maths lessons

Yes	17%
No	83%

APPENDIX 23:

Graphs for model checking for
learner background variables

Graphs for Model Checking: Demographic Variables

Figure 26: Residuals vs homework (model 3)

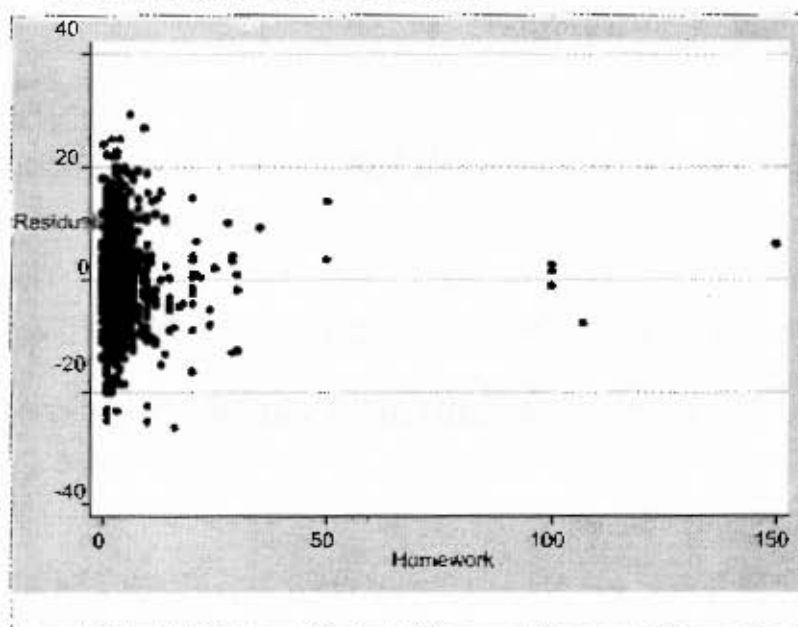


Figure 27: Histogram of residuals (model 3)

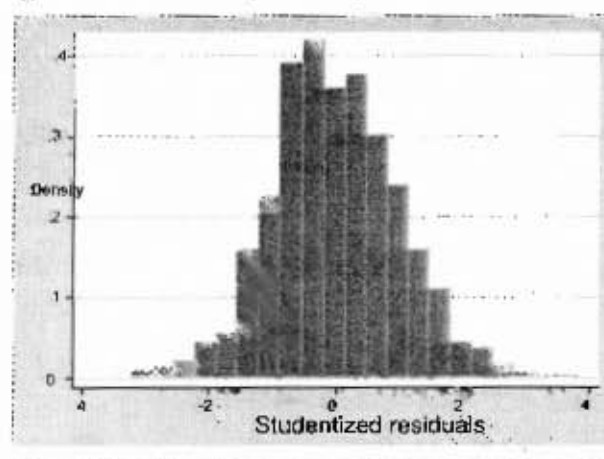


Figure 28: Normal probability plot (model 3)

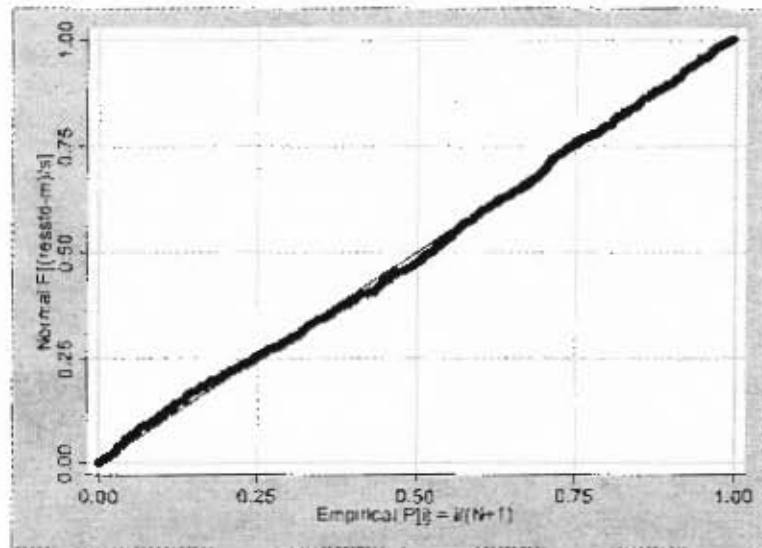
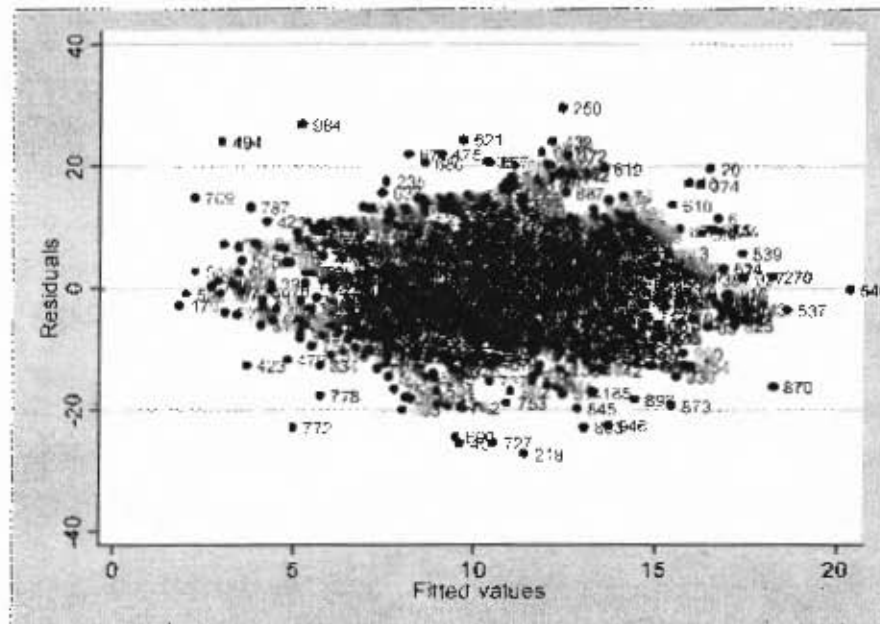


Figure 29: Checking for constant variance (model 3)



APPENDIX 24:

Boxplots for the interplay between the significant variables for OTL and 'type of pedagogy'

Boxplots for the interplay between the significant variables for OTL and 'type of pedagogy'

Figure 30: Content by cognitive demand and framing over micro sequencing

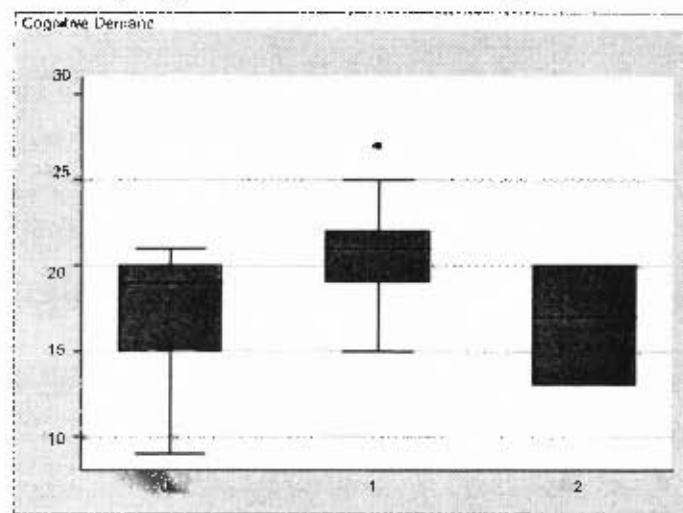


Figure 31: Content by cognitive demand and framing over criteria for evaluation (Evalcrit_pre)

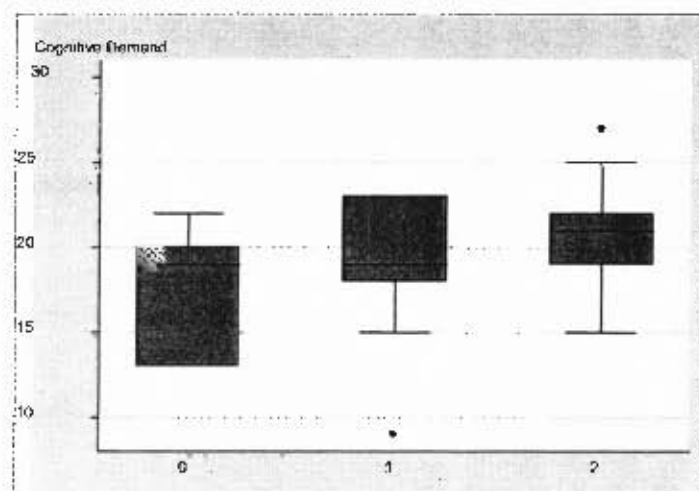


Figure 32: Content by cognitive demand and framing over criteria for evaluating texts for evaluation (Evalcrit_post)

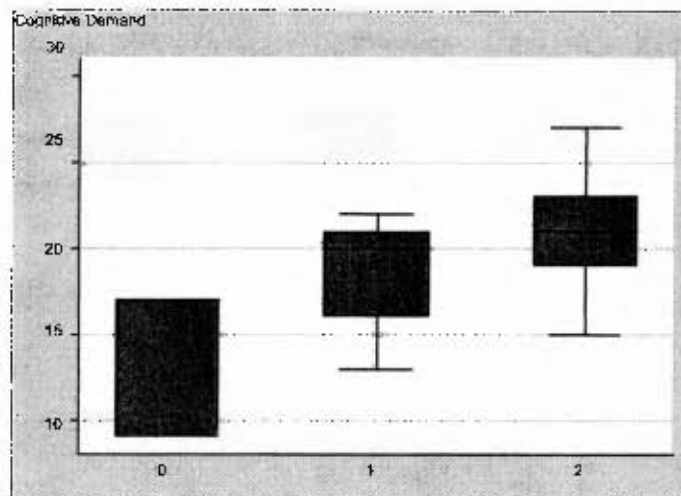


Figure 33: Logabsent and framing over micro Sequencing

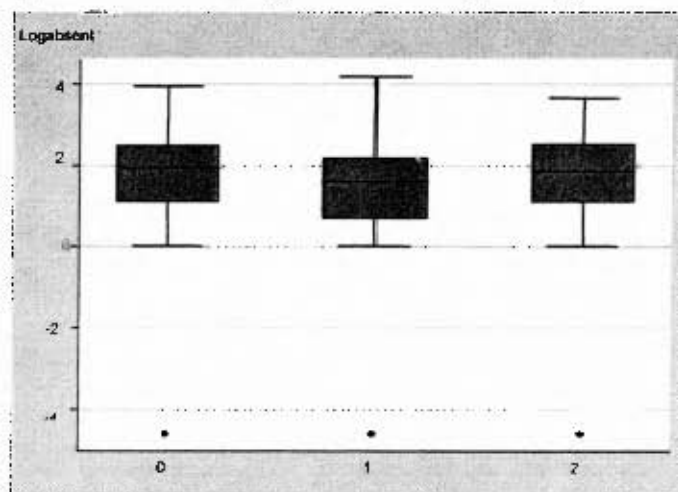


Figure 34: Logabsent and framing over evaluation criteria (Evalcrit_pre)

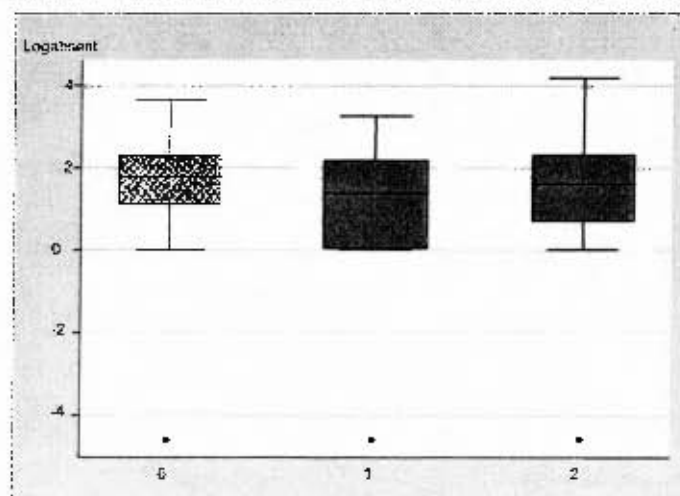
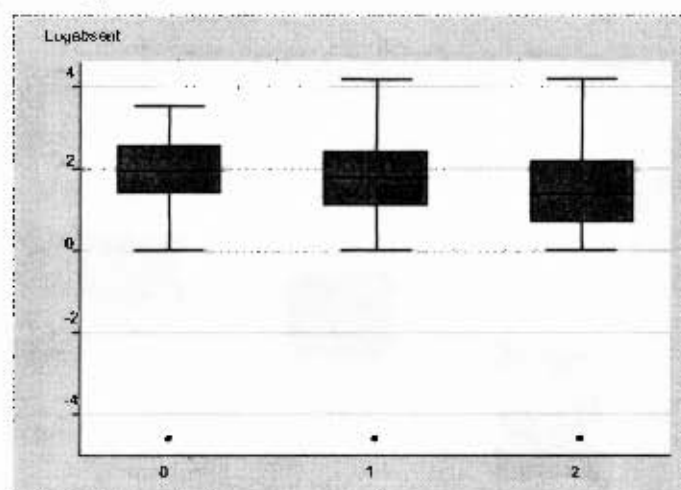


Figure 35: Logabsent and framing over criteria for evaluating texts for evaluation (Evalcrit_post)



APPENDIX 25:

Graphs for model checking for combined model

Graphs for Model Checking: Combined Model

Figure 36: Histogram of residuals (combined model)

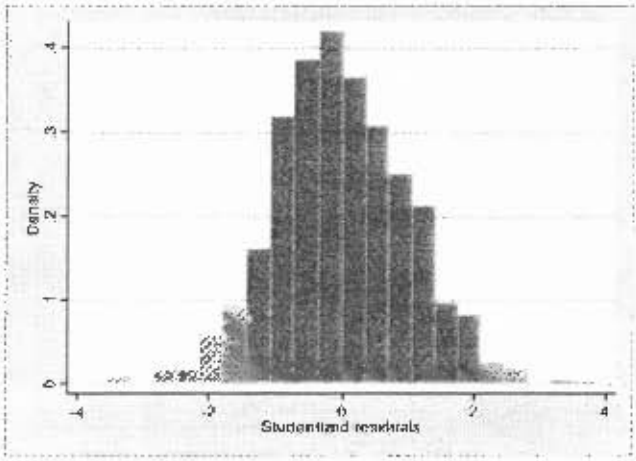


Figure 37: Normal probability plot (combined model)

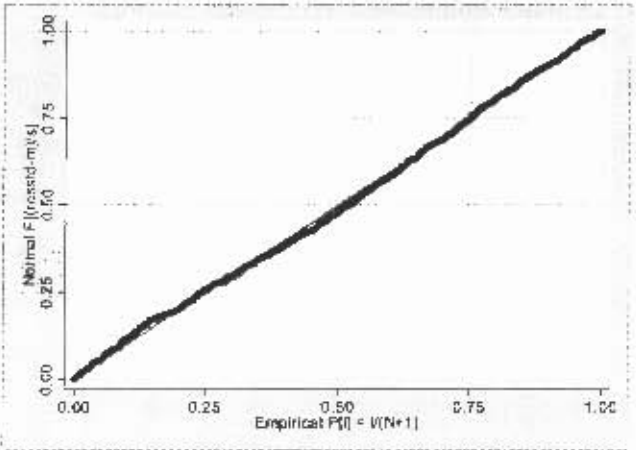
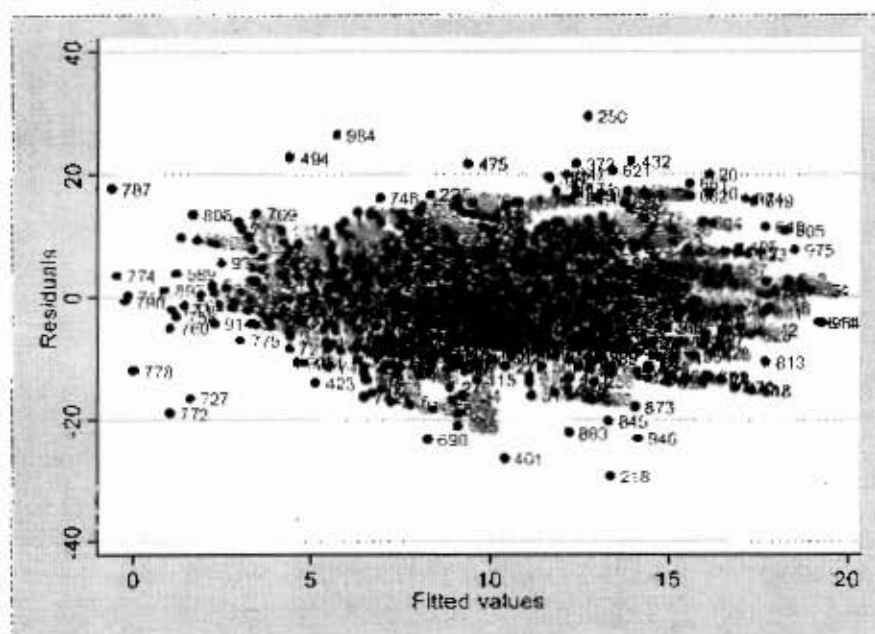


Figure 38: Checking for constant variance (combined model)



APPENDIX 26:

Diagnostics for the hierarchical linear modelling

Diagnostics for the HLM

Figures 39 - 43 below show diagnostic plots.

Figure 39: Normal probability plot - level 1 residuals (HLM)

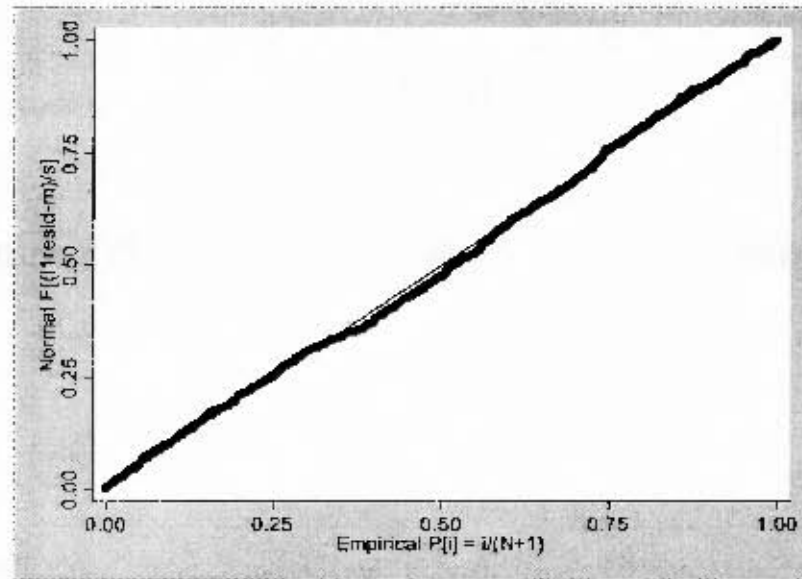


Figure 40: Normal probability plots - every 5th class (HLM)

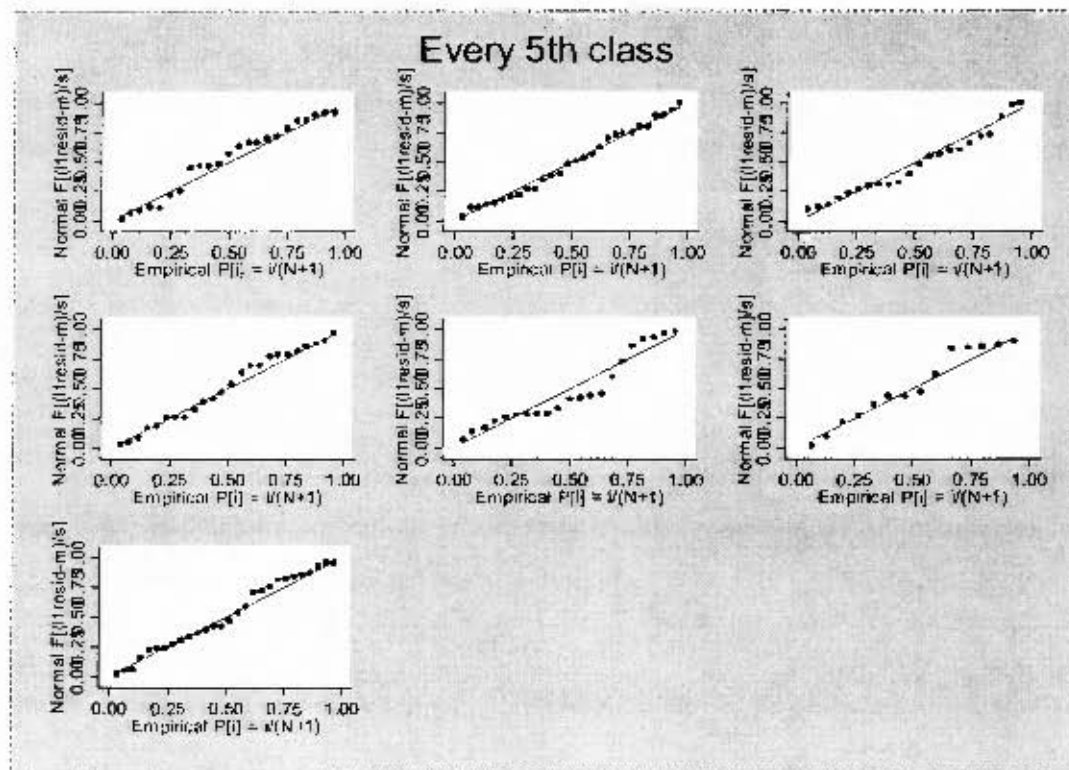


Figure 41: Normality of level 2 residuals (HLM)

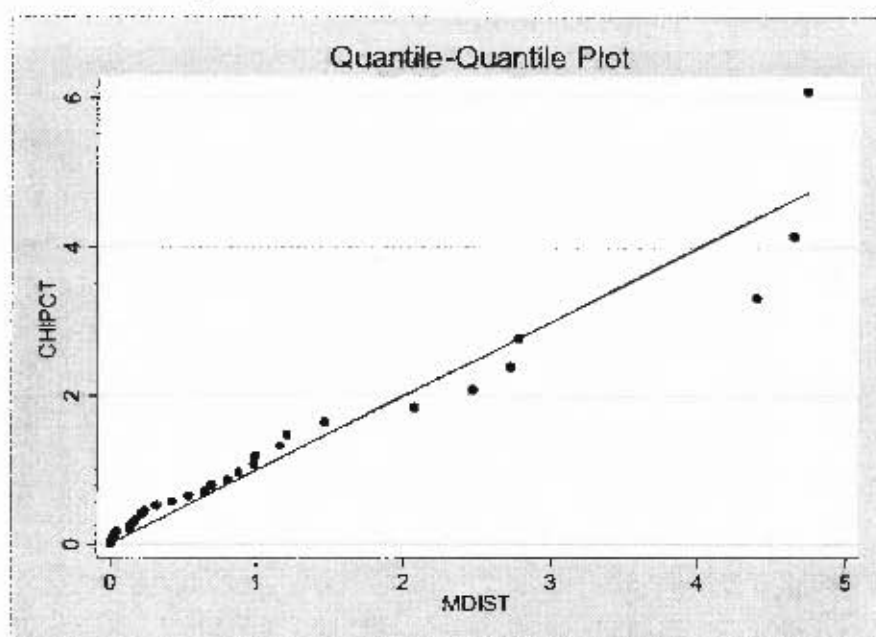


Figure 42: Homogeneity of level 1 variance (HLM)

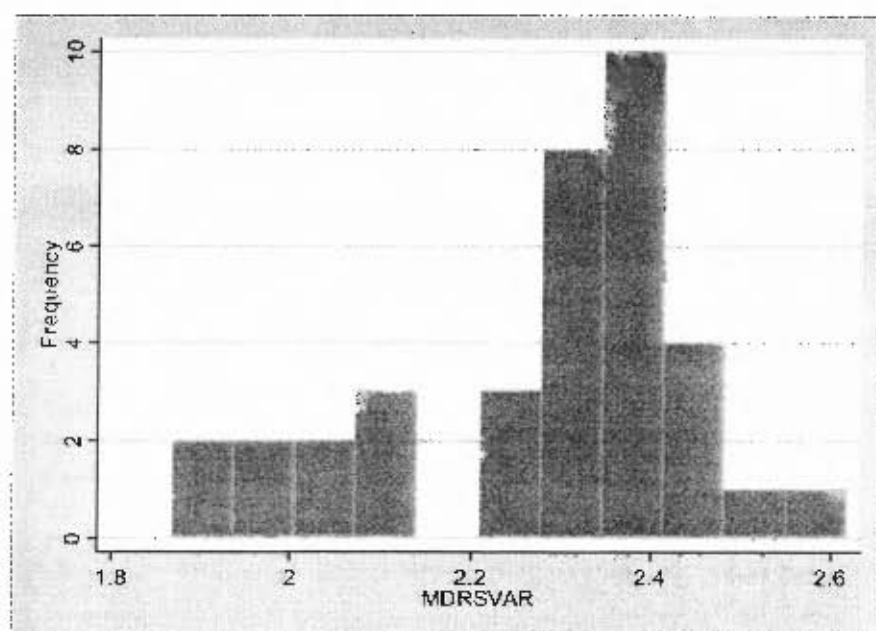


Figure 43: Residuals vs cognitive demand (HLM)

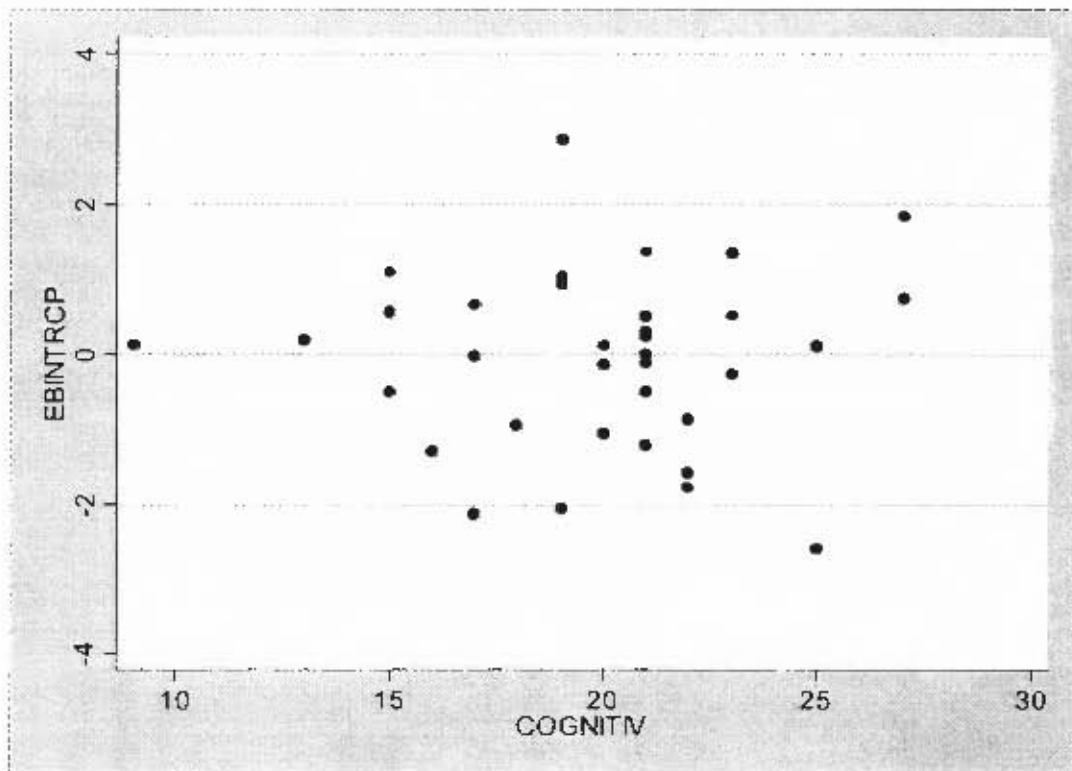


Figure 44: HLM screenshot



Normality of the residuals at level 1 was checked with a normal probability plot (figure 40) and the distribution of the residuals within each level 2 unit was checked by examining a random set of every 5th class (figure 41). These plots show that the level 1 residuals were approximately normal and this was confirmed with a Shapiro-Wilks test that had a pvalue of 0.42.

The normality of level 2 residuals was assessed by plotting the Mahalanobis Distance measure against the expected distance. Essentially the Mahalanobis Distance gives a single measure that summarises the distance of a unit's Empirical Bayes (EB) estimate from its fitted value. Figure 42 reveals that apart from a few classes (for example, 2, 10) the residuals appeared normal.

Homogeneity of variances across classes was assessed by looking at the frequency distribution of these standardised measures of dispersion. Figure 43 showed that this assumption appeared reasonable - however there are 2 classes with less variation than the others (classes 2 and 22).

In general one can check for potential model misspecification by plotting the residuals against several potentially interesting variables. But since most of the level 2 variables are categorical this could only be done for cognitive demand. A plot (figure 44) of the empirical bayes residuals versus cognitive demand revealed random scatter.